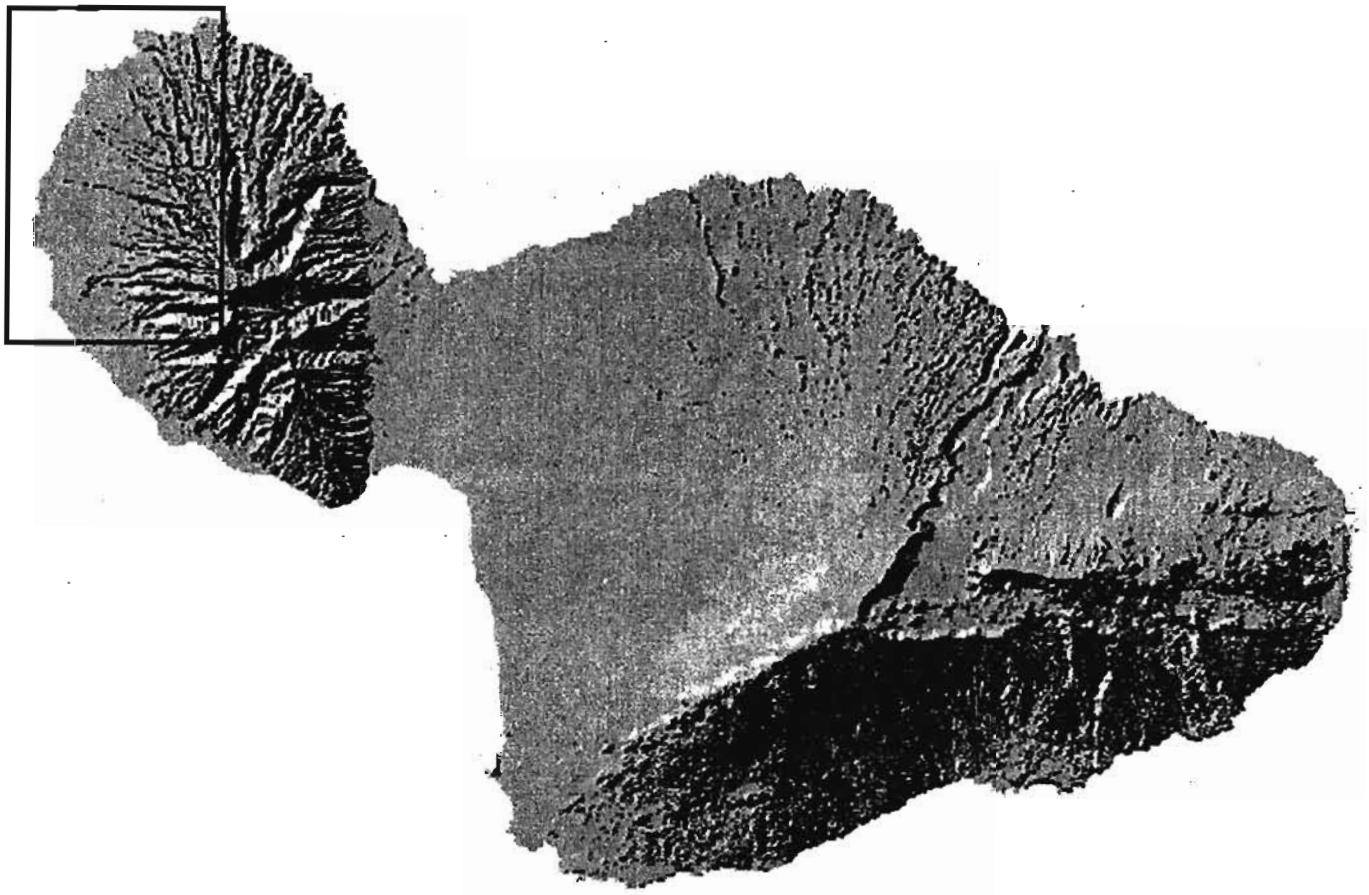
WEST MAUI WATERSHED OWNERS MANUAL

November 1997



Prepared by:
West Maui Watershed Management Advisory Committee
for
THE COMMUNITY

Funded by:
Hawaii Department of Health
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CONTENTS

WE ALL SHARE PERSONAL RESPONSIBILITY FOR PROTECTING OUR ISLAND'S PRECIOUS RESOURCES.

SUMMARY

1. Watershed Owners Manual

The West Maui Watershed Owners Manual is a collection of recommendations for protecting and improving water quality and ocean resources in West Maui. The Owners Manual recommends actions for all the watershed's residents and users, and identifies specific tasks for which the large plantations, government agencies, and individual residents should be responsible. It is a comprehensive plan for protecting both drinking water sources and coastal waters.

Recommendations spelled out in the Owners Manual include more erosion control for agricultural land and construction sites, improved management practices for landscape and agricultural fertilizer use, a protective program for drinking water supplies, better drainage designs for new developments, and more effective algae removal programs.

2. West Maui Watershed Management Project

The Owners Manual is the result of a community effort, the West Maui Watershed Management Project, that was initiated in response to public concern over nuisance algal blooms and muddy coastal waters. Recommendations were developed with the advice and participation of the West Maui Watershed Advisory Committee consisting of representatives from local businesses; federal, state, and local government agencies; private citizens, scientists, and West Maui Taxpayers Association.

The West Maui Watershed Advisory Committee established eight objectives for the Owners Manual. These are to (1) reduce soil erosion, (2) promote pollution prevention and waste minimization, (3) promote improved water management practices, (4) promote urban stormwater management that is protective of ocean water quality, (5) protect native forest ecosystems, (6) encourage algae clean-up and beneficial use, (7) promote voluntary watershed management activities and create incentives for their application, and (8) protect the economy, aesthetics and diversity of the community. There is a chapter of the Owners Manual devoted to each of the first 6 objectives. Objectives 7 and 8 guide the implementation of the other objectives.

A community-based watershed management process has been applied in many places around the country to address local environmental problems and user conflicts. This approach is designed to conserve the watershed's natural resources as well as support the interests and hopes of the human stakeholders in that system. A community watershed process can improve the integration of land and water management activities and promote the sharing of resources and responsibilities among stakeholders. Three projects supported by Hawaii Department of Health (the West Maui Project, and two Ala Wai Watershed Projects on Oahu) are the first projects of this kind in Hawaii and are intended to serve as models for other communities in the State.

3. Actions taken to control pollutants

Many actions to better manage land and water resources in West Maui have been taken during the 4 years of the West Maui Watershed Project. Some projects were specifically funded or organized by the West Maui Watershed Project; others were conducted by agencies and organizations involved in the Watershed Advisory Committee.

Recent actions taken to reduce pollutant loads and protect West Maui's water resources include (1) construction of 10 new sediment retention basins, (2) new erosion control best management practices

at 22 locations on Maui Pineapple Company's Honolua Plantation, (3) proposed revisions to Maui County's Erosion and Sediment Control (Grading) Ordinance, (4) two pollution prevention booklets: "Island Stewardship: Guide to Preventing Water Pollution for Maui's Homes and Businesses" and "What Boaters Can Do to be Environmentally Friendly," (5) reductions in nitrogen and phosphorus loadings to Lahaina's wastewater injection wells by over 60%, (6) a new County Ordinance on "Use of Reclaimed Water," (7) irrigation of Kaanapali Golf Course with 1.3 mgd of reclaimed water, (8) delineation of wellhead protection areas for all drinking water wells, and (9) a new business that collects drifting algae and converts it into commercially valuable products including potting soil and liquid fertilizer, (10) a pilot "bounty" program to pay youth groups for removing algae from beaches, and (11) a volunteer coastal monitoring project.

4. Research findings and recommendations

A research program was undertaken to investigate the causes of nuisance algal blooms, in conjunction with the West Maui Watershed management project. Concern about algae first surfaced in 1989 when a mysterious bloom of the green alga, *Cladophora*, tangled on reefs and washed ashore to rot on West Maui's beaches. *Cladophora* has reappeared as a problem only once, in 1991. Since then, piles of two other algal species, *Hypnea* and *Ulva*, have become a regular feature in Kahului Harbor and on beaches in West Maui, Kihei, Sprecklesville and Kuau.

Studies focused on the red alga, *Hypnea*, which has been a problem on West Maui beaches for about 10 years. *Hypnea* is not native to Hawaii and was introduced to Kaneohe Bay, Oahu, in 1974. *Hypnea* is not expected to disappear or decline rapidly in the near future. Like many introduced species, *Hypnea* has become a nuisance that spreads rapidly and appears to lack natural controls, which can include competition from other algae, grazing by fish and other marine organisms, and even disease.

The research confirmed that nutrients from land-based sources are necessary to support the amount of algae growing in West Maui. The major source of nutrients supporting the growth of *Hypnea* is the steady seepage of groundwater along the shore. Ocean currents and stream runoff also bring nutrients to the areas where algae are thriving, but these sources proved to be small when compared to inputs from groundwater. Natural groundwater contains higher nutrients than oceanic water and nutrient levels are increased further by man's activities on land, primarily from fertilizers used on agricultural crops and landscaping, and disposal of sewage in cesspools.

Wastewater injection wells were not shown to be a significant source of nutrients for *Hypnea*. Nutrients from injection wells apparently enter the ocean in deeper water than that where *Hypnea* occurs.

Many factors influence algal distribution and growth. These factors are poorly understood at present. In the case of nutrients, more experimental work is planned to determine whether or not reducing nutrients from human activities on land will have a measurable effect in controlling *Hypnea's* abundance in West Maui.

Cladophora blooms were not studied directly because no bloom occurred during the study period. Some researchers think that the most likely land-based trigger for the *Cladophora* blooms in 1989 and 1991 was the unusually large rainfall periods that preceded both blooms.

Studies of sediment runoff and coastal turbidity indicate that most of the sediment loss occurs on agricultural land. Runoff from forests contributes about 25% of the sediments in West Maui's streams. Stages

most vulnerable to erosion were identified as (1) the first year after planting for pineapple and (2) the period between harvesting and 4 months after planting for sugar cane. Runoff from urban areas was found to have high concentrations of phosphorus from landscape fertilizers.

The West Maui Watershed Advisory Committee made the following recommendations based on the research findings:

- Develop additional best management practices to improve erosion control on agricultural land.
- Promote the use of best management practices to reduce runoff and leaching of fertilizers used for landscaping.
- Continue to improve the use and efficiency of best management practices for agricultural fertilizers.
- Promote beach cleaning and harvesting of drifting algae to help control nuisance accumulations of algae.
- Expand investigations of algal blooms and the watershed management approach to be island-wide.
- Conduct additional research to evaluate whether eliminating coastal cesspools will reduce *Hypnea* biomass; determine whether phosphorus is a limiting nutrient for algal growth; and map the nuisance algal populations in other areas of Maui with adjacent land uses.

5. Recommendations to improve land and water management in West Maui

Additional recommendations designed to improve land and water management practices in West Maui are included for the first 6 objectives of the Owners Manual. Each chapter provides background on the environmental concerns and describes what is now being done to address the concern. Specific tasks and the parties responsible for their implementation are listed for each objective. These are summarized below and the agencies or organizations responsible for implementation are shown in parentheses.

RECOMMENDATIONS

Watershed Objective 1.

Reduce soil erosion throughout the watershed

1A. Reduce soil erosion on agricultural land.
(DOH, MPC, PMC, NRCS, WMSWCD)

Further improve erosion control on agricultural land.

Target drainage basins upland from high turbidity coastal areas for aggressive erosion control.

1B. Promote the use of sediment retention basins to prevent sediments from entering the ocean.

Construct new sediment retention basins at Honokeana, Kaopala, Hahakea, and Kahoma. (NRCS, WMSWCD, COE)

Agencies and Organizations

BWS	Maui County Board of Water Supply
CG	Coast Guard
COE	U.S. Army Corps of Engineers
DLNR	Hawaii Department of Land & Natural Resources
DOH	Hawaii Department of Health
MC	Maui County Dept. of Public Works & Waste Management
MPC	Maui Pineapple Company
NOAA Sanctuary	National Oceanic & Atmospheric Administration's Hawaiian Islands Humpback Whale National Marine Sanctuary
NRCS	Natural Resources Conservation Service
PMC	Pioneer Mill Company
TNC	The Nature Conservancy
WMSWCD	West Maui Soil & Water Conservation District
WMWMP	West Maui Watershed Management Project

Expand sediment retention capacity by (1) adding small basins in series, or (2) deepening existing basins. (NRCS)

Assure regular cleaning and maintenance of sediment retention basins. (MPC, MC)

1C. Reduce soil loss at construction sites. (DOH, MC)

Revise the Grading Ordinance and provide training program and manual for inspectors and construction industry.

Improve inspection and enforcement of requirements for erosion control.

Watershed Objective 2.

Promote pollution prevention and waste minimization

2A. Promote pollution prevention for homes and businesses.

Develop a public education program based on the booklet "Island Stewardship: Guide to Preventing Water Pollution for Maui's Homes and Businesses." (DOH, MC, NOAA Sanctuary)

Develop a household hazardous waste disposal program. (MC)

Develop Pollution Prevention Plans for West Maui's sugar cane, pineapple, and coffee agriculture with focus on fertilizers, pesticides and erosion control. (DOH, NRCS, WMSWCD)

Develop a pollution prevention training and certification program for Maui's hotels, condos, and golf courses. (DOH, WMWMP)

More education for landscape industry on improving efficiency of fertilizer use. (Landscape Industry Council of Hawaii, UH Extension Service)

2B. Promote pollution prevention for boats

Develop an educational program for boaters based on booklet "What Boaters Can Do to Be Environmentally Friendly." (DOH, DLNR)

Improve use of pumpout facilities and observance of marine toilet rules. (CG, DLNR)

Develop local capacity to respond to oil spills. (CG)

Watershed Objective 3.

Promote improved water management

Expand water conservation efforts. (BWS, Kaanapali Water Company, Kapalua Land Company Water Department)

Expand use of reclaimed water, especially for agricultural and landscape irrigation. (MC, DOH)

Evaluate the contribution of coastal cesspools to nuisance algal blooms and recommend appropriate management strategy. (DOH, MC, WMWMP)

Develop a source water protection program for drinking water supplies. (BWS, DOH, TNC, landowners)

Watershed Objective 4.

Promote urban stormwater management practices that are protective of ocean water quality

Incorporate stormwater management practices designed to protect ocean water quality into plans for new development. (MC)

Reduce polluted runoff from existing development. (MC)

Improve the design of flood protection and drainage channels. (COE, NRCS, MC)

Watershed Objective 5.

Protect native forest ecosystems

Form a partnership of landowners to coordinate management of native forest in the West Maui Mountains. (BWS, TNC, DLNR)

Expand educational efforts to prevent spread of alien species. (DLNR, TNC)

Develop recommendations for protecting other native ecosystems including streams, riparian areas, wetlands, and coral reefs. (DLNR)

Over half of the tasks identified in the Owners Manual are now underway. It is up to individuals on a voluntary basis to carry out the recommendations.

He ali'i ka 'aina, he kauwa ke kanaka.

"The land is royalty and people are its servants."

Watershed Objective 6.

Encourage algae clean-up and beneficial use

Develop more effective methods for removing algae from shoreline. (MC, WMWMP)

Monitor severity of algae problem and effectiveness of control measures. (WMWMP)

Develop beneficial uses for *Hypnea.* (MC, WMWMP)

Increase numbers of herbivores in areas with *Hypnea.* (DLNR)

Table 1. West Maui Watershed Management Advisory Committee membership list.

Dr. Wendy Wiltse, Hawaii Dept. of Health, Coordinator

Dr. June Harrigan-Lum, Lead for Department of Health

George Kaya, Mayor's Office, Maui

Christine Andrews, University of Hawaii

Gina Aranki, West Maui Taxpayers Association

Janet Ashman, Hawaii Agricultural Research Center

Eve Clute

Robert Derks, Kapalua Land Company

Dr. Steve Dollar, U.H. School of Ocean and Earth Science and Technology

Jeff Eng, Kaanapali Resort

Kimo Falconer, Pioneer Mill Co., Kaanapali Estate Coffee, Inc.

Neal Fujiwara, Natural Resource Conservation Service, Maui

Don Gerbig, AMFAC

David Goode, County of Maui, Dept. of Public Works and Waste Management

Wil Leon Guerero, Hawaii Dept. of Agriculture

Skippy Hau, State Dept. of Land and Natural Resources, Division of Aquatic Resources

Ellen Kraftsow, Maui Board of Water Supply, Water Resources and Planning Division

Dennis Nakamura, Maui County Council

Buddy Nobriga, West Maui Soil and Water Conservation District

Wesley Nohara, Maui Pineapple Company

Steve Parabicoli, County of Maui, Dept. of Public Works and Waste Management, Wastewater Reclamation Division

Dr. Frank Peterson, U.H. Dept. of Geology and Geophysics

Dr. Glenn Shepherd, Retired Geologist

Will Spence, Maui Planning Department

Daren Suzuki, Maui Planning Department

Marty Stevenson, Kinnetic Laboratories, Inc.

Allen Tom, NOAA Hawaiian Islands Humpback Whale National Marine Sanctuary

Mark White, The Nature Conservancy

INTRODUCTION

Watershed Owners Manual

The Owners Manual is a product of four years' discussion and work by West Maui community members and government representatives on the West Maui Watershed Management Advisory Committee. It is a collection of recommendations to protect and improve the water quality and ocean resources of West Maui. It is intended as a guide for land, water, and waste management practices within the watershed, to be applied to ongoing and future activities. Similar to your car's owners manual, it is up to individuals on a voluntary basis, to carry out the Watershed Owners Manual's recommendations.

The Owners Manual is the result of a process, the West Maui Watershed Management Project, initiated in response to community concern over nuisance algal blooms and turbidity of coastal waters. The recommendations were developed with the advice and participation of community representatives; federal, state, and local government agency representatives; private citizens; and local citizen interest groups. The Owners Manual is a living document; recommendations should be reviewed for effectiveness and completeness over time and revised as needed.

This Manual is organized by the objectives that were defined by the West Maui Watershed Management Advisory Committee. The Introduction describes the origins, approach, goal and objectives, and accomplishments of the West Maui Watershed Project. Chapters 1-6 each focus on a specific objective. These chapters include a background section, statements of objectives, and lists of specific tasks recommended to accomplish the objectives. The implementation of specific tasks is, for the most part, up to the voluntary efforts of stakeholders in the community such as County government, land owners, residents and businesses. A listing of government agency roles for implementing recommendations, both voluntary and as mandated by federal, state and county regulations, is included in Appendix C. The Owners Manual, as formulated by the West Maui Watershed Advisory Committee, is a guide for ongoing and future activities.

To assist in measuring progress and tracking the effectiveness of management efforts in West Maui, a group of six "Measures of Progress" was defined by the Watershed Advisory Committee. A report on the current status of these measures, and what has been accomplished toward the Watershed Project's goal and objectives is included in this Introduction.

What is a watershed?

"Watershed" is a term used to describe the land area drained by a particular stream, and includes the water resources (lakes, streams, wetlands, and groundwater) in that drainage basin. A watershed parallels the Hawaiian concept of ahupua'a. It includes the land from the mountains to the coast that drain into a stream, and the coastal ocean extending out to the seaward edge of the coral reef.

For the purposes of the West Maui Watershed Management Project, we arbitrarily defined our watershed as all the land and water resources that drain into the segment of shoreline that has been impacted by nuisance algal blooms. As a result of our decision, our work has focused on the land and shoreline from Kapalua to Puamana (Fig. 1). This area encompasses a series of ahupua'a. Approximately 50% of the land area is forested conservation land, 40% is agricultural, and 10% adjacent to the shoreline is considered urban (residential, resort, commercial).

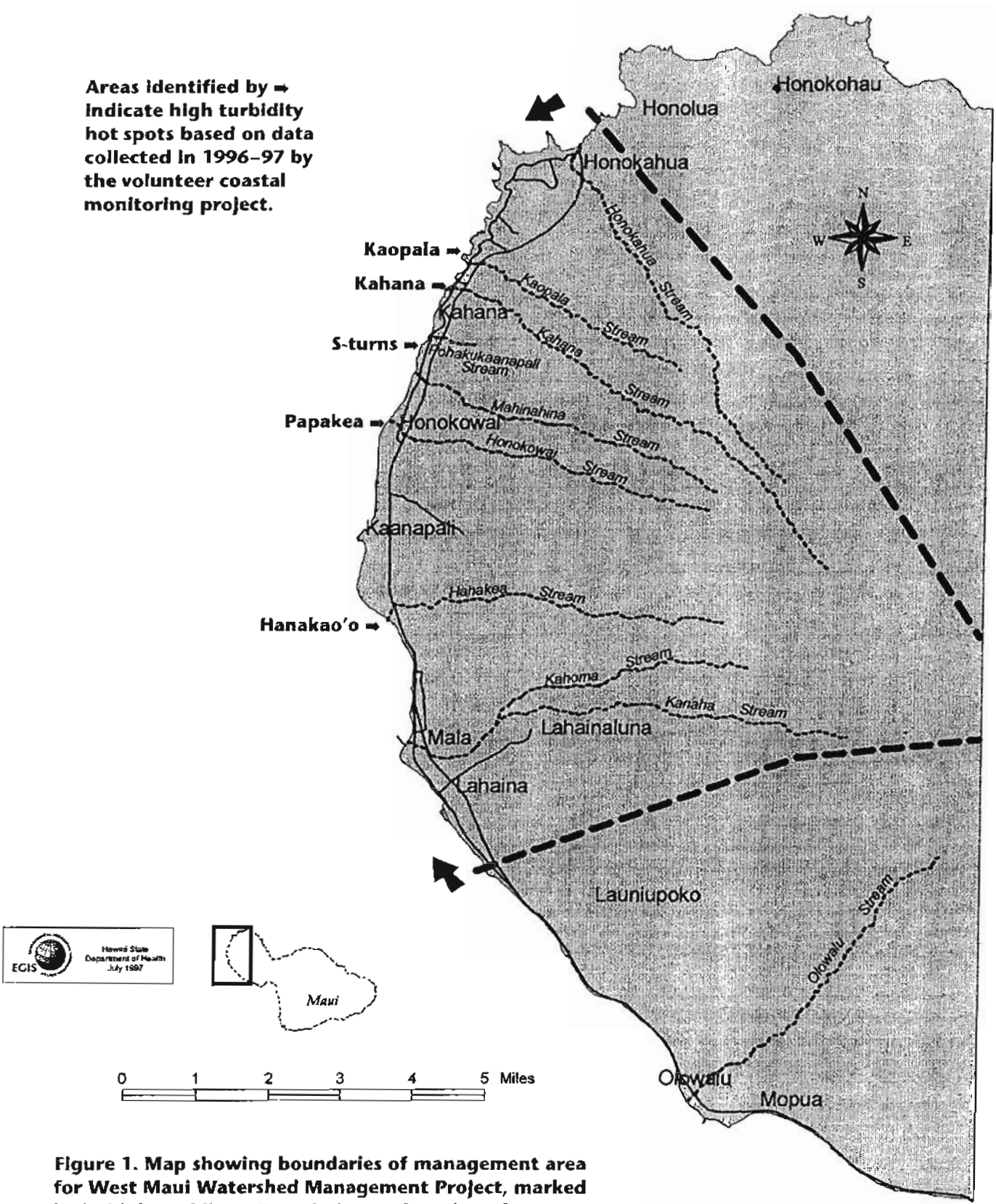


Figure 1. Map showing boundaries of management area for West Maui Watershed Management Project, marked by bold dotted lines. Boundaries are based on the range of nuisance algal problems along the shoreline.

The watershed approach: A new model for environmental management

The West Maui Watershed Project follows a model for community-based environmental management that has been applied in many places around the country, including Napa Valley and Monterey Bay in California, Puget Sound River Basin in Washington, and the Anacostia River Basin in Maryland.

Community-based watershed management is a *process* which brings together stakeholders (citizens and agency partners) in a specific geographic area — a watershed or drainage basin — to examine the actual and potential environmental impacts of present and planned land uses, and to implement pollution control and habitat management activities. Watershed management goals include protection of public health, environmental health, and community quality of life, and are not limited to the interest or authority of a single agency or stakeholder.

The model or process is designed to address the need to conserve the watershed's natural resources as well as support the interests and hopes of the human stakeholders living in that system. The model has 5 steps: (1) identify stakeholders, (2) identify interests and specify goals and objectives, (3) evaluate management options in terms of interests, (4) define criteria for success and develop a method for measuring them, (5) develop an action plan and implement the options, and (6) review the interests and actions for effectiveness and adjust as necessary.

Effectively involving the community in environmental management is a time-consuming approach but one that promises a successful program with return on investments of time and energy. The goal of the management process is to establish, over time, trust and cooperation among stakeholders. Consensus-building, in the form of a round-table discussion, is a key component. Advantages of this approach include:

- Integrated approaches where the entire system is considered rather than the interest or authority of individual stakeholders;
- Opportunities to form partnerships to share resources and responsibilities;
- Fostering a long-term perspective on resource management;
- Fostering voluntary participation by stakeholders; this approach can be more effective than enforcing compliance with mandates;
- Establishing a mechanism for addressing new resource management concerns; and
- Flexibility to change approaches in response to new information or ideas.

Origins of the West Maui Watershed Management Project

The West Maui Watershed Project grew from a legacy of concern in the West Maui community about nuisance algal blooms and muddy coastal waters. These efforts began in the 1960s and 70s with West Maui Soil and Water Conservation District's series of watershed plans to "provide effective land treatment on watershed land and to prevent floodwater and sediment damage in the flood plain and discoloration of the ocean along the coast." An upwelling of concern about the *Cladophora* algal blooms in 1989 and 1991 and a "500 year storm" in July 1993, led to both scientific research into the causes of nuisance algal blooms in West Maui and the initiation of new management practices designed to reduce inputs to the ocean of pollutants from land.

An "Algal Bloom" Task Force of community members and scientists was convened in 1992. The Task Force produced

HOW YOU CAN PARTICIPATE

Volunteer with Na Pale O Ke Kai to help monitor coastal health. Track the proliferation of an introduced species of algae, or monitor the clarity of coastal waters. Call 879-2818 or 667-0437.

Help mark storm drains with signs "DO NOT DUMP, DRAINS TO OCEAN." Call Community Work Day 243-7325.

Attend conferences and public meetings to become informed and give feedback on conditions in your area.

Read this Owners Manual and work to implement some of the recommendations. Write letters to the Planning Commission and County Council, or testify at meetings.

Encourage youth to participate in the "Bounty Project" to clean algae from beaches while raising funds for youth groups. Call 661-3042.

Read "Island Stewardship: Guide to Preventing Water Pollution for Maui's Homes and Businesses." Identify five or more actions you can take to help keep the ocean clean.

a report in August, 1992 recommending research and management actions to address the algae problem, and general recommendations for improving government response to marine environmental problems.

One of the recommendations of the Algal Bloom Task Force was to develop and implement an integrated watershed management plan for Maui that describes methods for reducing the amount of pollutants entering the ocean from all sources. To accomplish this goal, a community-based West Maui Watershed Management Advisory Committee (Advisory Committee) was formed in September 1993, under the coordination of Dr. Wendy Wiltse. This committee included members of the original Task Force as well as representatives of other interests in the community. The Advisory Committee members are listed in Table 1 on page 6.

A GOAL OF THE COMMUNITY-BASED WATERSHED MANAGEMENT PROCESS IS TO ESTABLISH, OVER TIME, TRUST AND COOPERATION AMONG STAKEHOLDERS.

Goal and objectives for the Watershed Project

The Advisory Committee established the following goal and objectives for the West Maui Watershed Management Project:

GOAL: To develop a community-based watershed management process to protect and improve the water quality and ocean resources.

OBJECTIVES:

1. Reduce soil erosion throughout the watershed.
2. Promote pollution prevention and waste minimization for fertilizers and toxic pollutants.
3. Promote improved water management practices.
4. Promote urban stormwater management practices that protect ocean water quality.
5. Protect native forest ecosystems.
6. Encourage algae clean-up and beneficial use.
7. Promote voluntary watershed management activities and create incentives for their application.
8. Protect the economy, aesthetics, and diversity of the community.

The Advisory Committee has met quarterly since 1993 to review research findings, organize community educational workshops, and make recommendations for achieving the project's goal and objectives. This Watershed Owners Manual is a major product of this collaborative effort.

Accomplishments

The following list of accomplishments is organized by objective. Some of the items have been specifically funded and organized by the West Maui Watershed Management Project (WMWMP); others were conducted by agencies and organizations involved in the Watershed Advisory Committee. The status of these accomplishments is indicated as "complete," "in progress" or "planned." Some of the accomplishments span more than one objective, but have only been noted once under the objective that is most applicable.

WATERSHED OBJECTIVE 1. Reduce soil erosion throughout the watershed.

A Community Workshop on "Runoff and Soil Erosion in West Maui" was held in February 1994. (WMWMP)

Twelve new sediment retention basins were completed, including major structures at Honokowai, Mahinahina, Pohakukaanapali, "Noname," Kaopala, Honokeana and Wahikuli, bringing the total number of sediment retention basins in the watershed to 21. (Natural Resource Conservation Service, West Maui Soil and Water Conservation District, Maui Pineapple Company, Maui County)

Most sediment retention basins in West Maui have been cleaned of accumulated sediment since 1994 and cleaning continues on an "as needed" basis. (Maui County, Maui Pineapple Company, Kapalua Land Company)

Figure 2. A volunteer with Na Pale O Ke Kai, Donna Liddicotte, collects water samples for turbidity testing.

New erosion control best management practices have been completed at 22 locations on Maui Pineapple Company's Honolua Plantation. (West Maui Soil and Water Conservation District, Maui Pineapple Company)

More sediment retention basins and best management practices are being installed for pineapple fields in the Honolua Bay drainage area. (West Maui Soil and Water Conservation District, Maui Pineapple Company)

The Sediment and Erosion Control (Grading) Ordinance is being revised to require that best management practices be used at construction sites to prevent runoff from construction sites from polluting streams and coastal waters. (Dept. of Public Works and Waste Management)

Training sessions in erosion control best management practices for the construction industry and for County inspectors are planned for 1997. (Dept. of Public Works and Waste Management)

The Environmental Quality Incentive Program (EQIP) administered through NRCS has targeted West Maui as a priority area for funding erosion control projects.

WATERSHED OBJECTIVE 2. Promote pollution prevention and waste minimization for fertilizers and toxic pollutants.

A workshop on "Pollution Prevention for Hotels" was held in September 1994. (WMWMP)

A workshop on "Pollution Prevention for Condos, Apartments and Homes" was held in November 1994. (West Maui Taxpayers Association)

Funds are secured to hire an expert contractor to provide training and technical assistance for hotels and condos on pollution prevention practices that they can use to prevent water pollution. (WMWMP)

A workshop on landscape fertilizer practices was held in February 1995 for engineering staff at hotels and condos. A presentation by the WMWMP was included.

A book, "Landscape Management Guidelines," was released by the Landscape Industry Council of Hawaii in July 1996.

A booklet called "What Boaters Can Do to Be Environmentally Friendly" is available to help educate boaters at Lahaina Harbor about common sense approaches for preventing water pollution. This is available from the Harbor Agent at Lahaina Harbor. (WMWMP, Hawaii Department of Land and Natural Resources, Lahaina Harbor-Mala Wharf Advisory Committee, DOH)

A booklet called "Island Stewardship: Guide to Preventing Water Pollution for Maui's Homes and Businesses" is available at public libraries on Maui. (DOH, WMWMP)

WATERSHED OBJECTIVE 3. Promote improved water management practices.

A workshop on "Drinking Water and Wastewater in West Maui: Now and the Future" was held in May 1994. (WMWMP)

Maui County adopted a new ordinance "Use of Reclaimed Water," Chapter 20.30 of the Maui County Code.

The Lahaina Wastewater Reclamation Facility has been upgraded to provide "R1" reclaimed water, suitable for irrigation of landscaping and crops. New treatment has reduced the concentrations and loads of nitrogen and phosphorus going to the injection wells by about 50% compared with 1993 levels.

Irrigation of Kaanapali Golf Course with recycled water began in May 1997. (AMFAC, Maui County)

A pilot project testing recycled water for pineapple irrigation is underway. (Maui Pineapple Company, Maui County)

Irrigation of sugar cane seed stock with recycled water is being evaluated. (Pioneer Mill, Maui County)

Maui County has an incentive program in process to retrofit old toilets with free water-saving toilet flappers (Dept. of Public Works and Waste Management) and showerheads with free water saving models. (Board of Water Supply, Maui Electric Company)

Delineation of wellhead protection areas for all of West Maui's drinking water wells is complete. (Board of Water Supply, Department of Health)

A wellhead protection program for Maui County is planned. (Board of Water Supply)

Information on water conservation and water-efficient landscaping is provided to developers and businesses during the permitting process. (Board of Water Supply)

Maui County has an active outreach program in public and private schools for promoting water conservation and reclaimed water use. (Wastewater Reclamation Division, Board of Water Supply)

WATERSHED OBJECTIVE 4. Promote urban stormwater management practices that are protective of ocean water quality.

A manual titled " Stormwater and Drainage Management Plan for West Maui" was completed by Woodward-Clyde Consultants (WMWMP) in 1996. The Plan describes existing stream hydrology and drainage conditions in the watershed, ranks segments of shoreline as to the severity of algae and turbidity problems, summarizes the current programs for the control of polluted urban runoff, and recommends improvements for control of runoff and flooding.

A storm drain stenciling effort has been initiated island wide to label inlets that drain to the ocean. (Community Work Day, NOAA Hawaiian Islands Humpback Whale National Marine Sanctuary, West Maui Taxpayers Association, WMWMP)

Hawaii's Coastal Nonpoint Pollution Control Program Management Plan, June 1996, recommends new runoff controls from construction sites and new development for localities like Maui where the Clean Water Act Stormwater Rules do not apply.

West Maui Community Plan encourages preservation of the natural functions of drainageways including infiltration, moderation of flow velocity, and removal of pollutants by filtration and biological action.

County Administrative Rules were revised giving the Dept. of Public Works and Waste Management authority to enforce in cases of illegal dumping.

WATERSHED OBJECTIVE 5. Protect native ecosystems.

Puu Kukui Preserve has been actively protected and managed for weeds and ungulates (pigs) since 1987. (Maui Land and Pineapple Company, The Nature Conservancy, Hawaii Department of Land and Natural Resources)

The forest of Kapunakea Preserve (1264 acres) has been actively protected and managed since 1990. (Pioneer Mill, The Nature Conservancy)

Discussions are in progress regarding expansion of forest protection areas and development of an integrated forest protection program for the West Maui Mountains. (C. Brewer Company, AMFAC, Maui Land and Pineapple Company, Bishop Estate, Board of Water Supply, and Department of Land and Natural Resources, and The Nature Conservancy)

WATERSHED OBJECTIVE 6. Encourage algae clean-up and beneficial use.

County contractors remove algae from beaches with heavy accumulations in Kahului and Kihei. (Dept. of Public Works and Waste Management)

A new business that will vacuum drifting algae from the water and convert it into commercially valuable products like liquid fertilizer and potting soil is being developed. (WMWMP, Oceanit Laboratories, Inc.)

Market research is underway to identify commercially valuable products that can be made with algae. (Maui County, Oceanit Laboratories, Inc.)

THE WEST MAUI WATERSHED MANAGEMENT PROJECT GREW FROM COMMUNITY CONCERN ABOUT NUISANCE ALGAL BLOOMS AND MUDDY COASTAL WATERS.

A pilot "bounty" program to pay youth groups for removing algae from beaches is being developed. (Maui County, West Maui Taxpayers Association)

WATERSHED OBJECTIVE 7. Promote voluntary watershed management and create incentives for their application.

Community leaders, land owners, activists, and agency representatives on the West Maui Watershed Advisory Committee have met quarterly since September 1993 to become educated about watershed problems and recommend management options.

"Land Stewardship Watershed Planning Workshop" with Dennis Bowker was held in February 1995. (WMWMP)

A Workshop "Protecting Coastal Waters: Tools for Local Governments" was held in March 1995. (WMWMP)

The Volunteer Coastal Monitoring Project, Na Pale O Ke Kai, is collecting important information about algae accumulations on beaches and water clarity while educating and empowering volunteers. (WMWMP)

Watershed Owners Manual provides recommendations for improving land and water management on a voluntary basis. (WMWMP)

The Goodyear Award recognizes outstanding landowners and soil and water conservation districts.

Natural Area Partnership Program is a cost sharing program to encourage large landowners to protect our native rainforest (DLNR, MLP)

WATERSHED OBJECTIVE 8. Protect the economy, aesthetics, and diversity of the community.

This objective guides the actions taken to forward all objectives.

Measures of progress

The Advisory Committee defined six measures of progress to track the effectiveness of management efforts in West Maui. These measures of progress toward the West Maui Watershed Project's Objectives are discussed below.

1. How bad is the nuisance algae?

Where is the algae now and is the problem spreading? (presence/absence)

Dollar and Andrews (1997) used a newly developed application, multispectral imaging, to map areas along the West Maui shoreline where attached *Hypnea* was abundant. The regions of high *Hypnea* abundance (from north to south) are Honokeana Cove (560 m of shoreline), Mahinahina Stream to S-turn Park (720 m), Wahikuli (920 m), and the shoreline between the Chart House Restaurant and Lahaina Cannery Mall (480 m). The total biomass of *Hypnea* was estimated to be approximately 7,800 kg dry weight. While the abundance of *Hypnea* may vary with the seasons and surf conditions, *Hypnea* is consistently present in these areas. Another area where *Hypnea* is consistently abundant, that was not detected by the imaging survey, is Alaeloa.

The range of distribution for nuisance algal accumulations on beaches in 1995-96 is reported by Hodges (1996) and the volunteer coastal monitoring project as:

West Maui: Launiupoko to Honokohau (*Hypnea* only)

South Maui: Maalaea to Kamaole III (*Hypnea* and *Ulva*)

North Shore: Paukukalo to Maliko (*Hypnea* and *Ulva*)

The presence/absence of accumulations of *Hypnea* and *Ulva* on 29 beaches sampled by volunteers was also reported by Hodges (1996) and provides a baseline from which to assess changes in the distribution of these two algae (Table 2). Beach sampling will be continued in 1997 as a component of Na Pale O Ke Kai, the name of the second year monitoring project.

Is the amount of algae increasing at specific locations?

The coastal monitoring project volunteers measured mean depths of accumulations at specific locations on a maximum of 25 dates between September 1995 and September 1996. Obviously, the amount of algae accumulated on a beach varies from day to day, and often with season, wind and surf conditions. Hodges (1996) reports the mean depth and standard deviation for all observations at the 29 beaches sampled by volunteers. Of the sites sampled, the beaches with the largest accumulations of algae for Sept. 1995 to Sept. 1996 are:

South Maui: Menehune Shores, Kalepolepo
West Maui: S-turns, Kahana Blue, and Honokeana Cove
North Shore: Paka Hou, Kanaha

2. How effective is the algae clean-up program?

To address this question, Cotton (1996) mailed a survey to all of the waterfront condominiums and hotels in West Maui, Maalaea, and Kihei in June 1996. Response to the survey was excellent, ranging from 50% in Maalaea to 93% in Kihei. Results are summarized below as percentage of responding properties

How many beaches have an algae problem?

West Maui = 78%
Maalaea = 80%
Kihei = 77%

What are the worst months?

West Maui = June-Sept.
Maalaea = Aug.-Nov.
Kihei = June- Sept.

Table 2. Presence (+) and absence (–) of *Hypnea* and *Ulva* reported from 29 beaches between Sept. 1995 and Sept. 1996. See Hodges (1996) for map of sampling sites.

Location	*Hypnea*	*Ulva*	Number of dates sampled
WEST MAUI			
Ukumehame	+	–	14
Launiupoko	+	–	7
Puamana	+	+	18
Hanaka'o'o	+	–	4
Wahikuli	+	+	1
Embassy Suites	–	–	1
Makani Sands	+	–	16
S-Turns	+	–	21
Alaeloa	+	–	1
Kahana Blue	+	+	6
Kahana Sunset	–	–	2
Honokeana Cove	+	+	4
SOUTH MAUI			
Mokapu	–	+	7
Keawakapu	–	+	19
Kamaole Sands III	+	+	14
Lipoa	+	+	24
Lipoa 3	+	+	4

Location	*Hypnea*	*Ulva*	Number of dates sampled
SOUTH MAUI (continued)			
Menehune Shores	+	+	21
Kalepolepo	+	+	25
Lori's Beach	+	+	22
Kihei Wharf (Suda)	+	+	24
NORTH SHORE			
New Park, Kanaha	+	+	15
Guard Tower	+	+	22
Halewa'a, Kanaha	+	+	2
Euro Beach	+	+	15
Baldwin Beach	+	–	16
Pa'ia Bay, West	+	–	23
Pa'ia Bay, Middle	+	–	20
Pa'ia Bay, East	+	–	18
Mantokuji Bay	+	+	20
Tavares Bay	+	+	12
Ku'au Bay	+	+	3
Ho'okipa, Seg. 1-3	+	–	2
Maliko	+	+	7

How many beaches have an algae removal program?

West Maui = 56%
Maalaea = 25%
Kihei = 65%

What is the annual clean-up cost?

West Maui = $28,940
Maalaea = $1,000
Kihei = $50,908

Are the present clean-up services effective?

West Maui = 29%
Maalaea = 25%
Kihei = 23%

Is assistance needed to help remove algae?

West Maui = 56%
Maalaea = 75%
Kihei = 50%

How much of the algae removed is used beneficially (not in landfill)?

~10%

3. How much sediment can we prevent from entering the ocean?

Two measures help to assess the amount of sediment prevented from entering the ocean: use of best management practices on land and turbidity in coastal waters.

The amount of sediment prevented from entering the ocean is indirectly assessed by tracking the use of best management practices in the watershed. The amount of sediment removed as part of the annual maintenance of sediment retention basins by Maui Pineapple Company and County of Maui is a meaningful measure. Had these basins not been in place, most of those sediments would have reached the ocean.

We assume that the more erosion control practices in active use, the lower the amount of sediment entering the ocean. Therefore another measure of soil prevented from entering the ocean is the number of Nonpoint Source Control Grants awarded by Department of Health. These grants, awarded under section 319(h) of the Clean Water Act, provide funding for improvements to protect surface and groundwater, and require a local cost share with the grant recipient.

How many sediment retention basins are in operation?

1993 = 11
1997 = 23
Planned = 1

How much sediment (cu yd) is removed from sediment retention basins?

1995 = 27,442
1996 = 18,174

Number of new Nonpoint Source Pollution Control Demonstration Grants awarded on Maui?

1993 = 0
1996 = 2
1997 = 1

The Nonpoint Source Pollution Control Grants are to (1) West Maui Soil and Water Conservation District (WMSWCD) to implement erosion control BMPs at 22 sites at Maui Pineapple Company's Honolua Plantation, (2) WMSWCD to build sediment retention basins and implement BMPs for Maui Pineapple Company's fields in the Honolua Bay drainage basin, and (3) Maui County for revisions to the Sediment and Erosion Control (Grading) Ordinance and training for inspectors and the construction industry.

Another approach to assessing the amount of sediment prevented from entering the ocean is to measure turbidity (water clarity) in coastal waters. As part of the coastal volunteer monitoring project, teams of volunteers are collecting turbidity data from 11 West Maui stations between Puamana in Lahaina Town and Napili Bay.

Table 3. Comparison of number of sediment retention basins existing in 1993 and 1997.

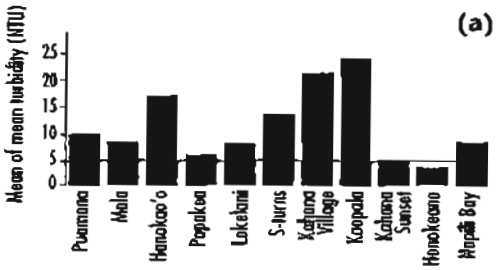
Drainage	1993	1997	Planned
Napili 2-3	3	3	
Napili 4-5	1	1	1
Honokeana	1	2	
Alaeloa	3	2	
Keonenui	1	1	
Kaopala	0	2	
Kahana	1	5[1]	
Noname	0	1	
Pohakukaanapali	0	2	
Mahinahina	0	1	
Honokowai	0	1	
Hahakea	0	0	
Wahikuli	0	1	
Kahoma[2]	1	1	
Kauaula	0	0	
TOTAL	11	23	

Table 4. Amount (cubic yards) of sediment removed from sediment retention basins each year. Blanks indicate that there is no record of sediment removal.

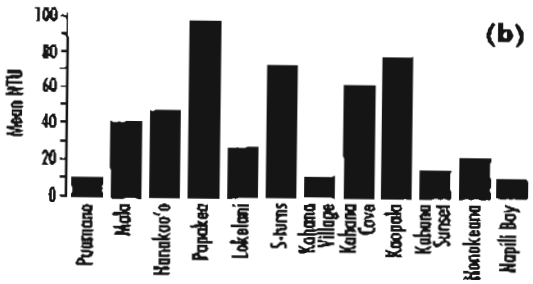
Drainage	1995	1996
Napili 2-3	2,304	750
Napili 4-5	4,550	
Honokeana	300	
Alaeloa		
Kaopala	192	240
Kahana	10,000	3,000
Noname		60
Pohakukaanapali	96	324
Mahinahina		
Honokowai		12,000
Kahoma	10,000	1,800
TOTAL	27,442	18,174

These data provide a measure of the normal variation in turbidity at each site and the persistence of turbidity after rainfall events. Both the range and persistence of turbidity can be compared over time as erosion control measures are implemented in the watershed (see Figures 3a and 3b).

Sites with the highest turbidity in both seasons were Kaopala and Kahana. Other sites with high turbidity include Hanakao'o, Papakea, and S-turns.



Samples from 11 West Maui shoreline sites, taken on 15 dates between April and September 1996, including one major rainfall event. Solid line indicates the applicable State Water Quality Standard for turbidity of 5 NTU, under wet conditions. The standard of 1.5 NTU applies under dry conditions. Data from Hodges (1996).



Samples from 12 West Maui shoreline sites, taken on 24 dates between December 1996 and March 1997, including several major rain events. Data from Bernard (1997).

Figure 3. Mean Turbidity values in Nephelometric Turbidity Units (NTU).

[1] Four sediment retention basins in the Kahana drainage basin are located on the edge of fields rather than in the stream.

[2] The basin in Kahoma Stream is technically designed to trap large debris, not sediments.

4. How much nitrogen and phosphorus can we prevent from entering the ocean via wastewater, agricultural and landscaping fertilizer?

We estimated the amounts of nitrogen and phosphorus entering the ocean from different sources on land (Table 5). Although there is much "uncertainty" in the estimates, they were based on the best available information, including new data generated by recent research. Tetra Tech Inc. presented a preliminary assessment of nutrient applications for different land uses and estimated the loads from these sources that actually enter the ocean. The values presented here represent modifications of the Tetra Tech work, taking new information into account. The information presented here compares estimated nutrient loads in 1991-92, before the initiation of the West Maui Watershed Management Project and in 1996, three years after the beginning of the WMWMP.

Inputs of nutrients to the coastal ocean have declined markedly between 1991-2 and 1996. While wastewater remains the largest potential source of nutrients entering the ocean, both the nitrogen and phosphorus loads have decreased by >50% as the result of upgrades in the level of treatment at the Lahaina Wastewater Reclamation Facility. Wastewater loadings declined by another 25% recently when Kaanapali began using 1.3 mgd reclaimed water to irrigate its golf courses and landscaping. It should also be noted that studies of the wastewater injection wells have not detected a distinct plume where the wastewater enters the ocean. Therefore, it is likely that highly diluted wastewater seeps from the ocean floor into the water column over a large area in deep water. In contrast, shallow brackish ground water, containing elevated concentrations of nitrogen from cesspools and the leaching of fertilizers applied to land, enters the ocean along the entire shoreline through distinct seeps in shallow water.

5. How many hotels and condos use pollution prevention practices, including water conservation, storm water control, and landscaping?

A questionnaire was sent to 28 hotels and 153 condominiums on Maui in summer 1997 to collect information on water conservation, energy conservation, buildings and maintenance, and landscaping practices (Grupenhoff, 1997). Thirty-five properties responded. Although the response rate was low, this survey does provide useful baseline information on current practices and helps to identify areas of focus for a future pollution prevention assistance program.

Some of the key results of the survey are reported below as percentage of properties responding.

Table 5. Estimated loadings of nitrogen and phosphorus (pounds/day) to ocean from various land sources in West Maui watershed.

Source	Nitrogen		Phosphorus	
	Pre-1993	1996	Pre-1993	1996
Wastewater injection wells	449	150	286	83
Wastewater cesspools	43	43	4.3	4.3
Pineapple	31	31	1.62	0
Sugar cane	36	36	0.7	0.7
Golf courses	2.2	2.2	0.7	0.7

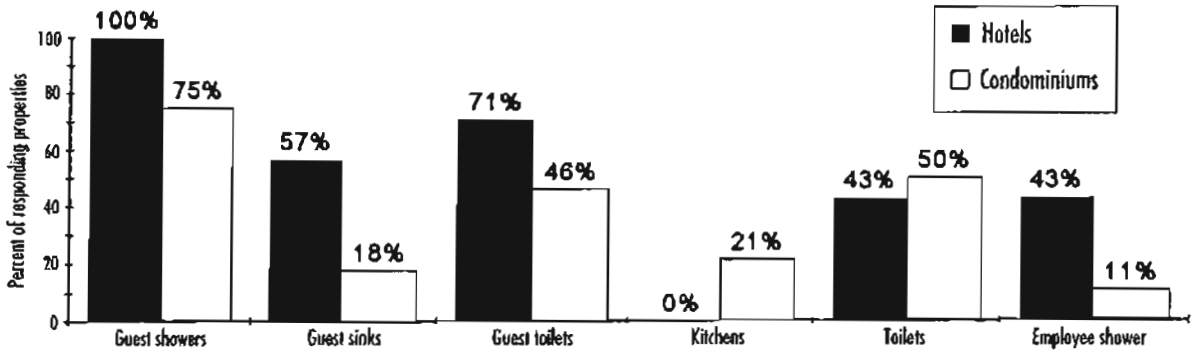


Figure 4. Use of low-flow plumbing fixtures by hotels and condominiums on Maui, from 1997 survey.

5A. Water conservation

Hotels and condominiums are using low-flow devices in a range of their facilities (Figure 4). Shower heads in guest rooms are the most commonly used low-flow fixtures. There is potential for more water savings from broader use of low-flow adapters for toilets.

The use of low-flow plumbing fixtures by hotels has increased since 1994 (Figure 5). The largest increases in use of low-flow fixtures were reported for guest toilets and employee restrooms.

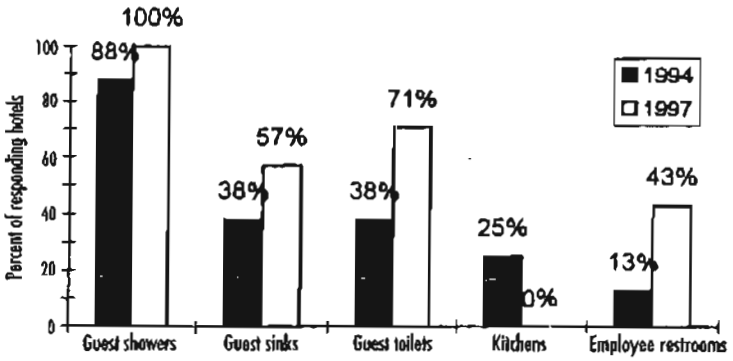


Figure 5. Comparison of the use of low-flow plumbing fixtures by hotels in 1994 and 1997.

Properties that give guests the opportunity to select how often sheets and towels are changed:

Hotels = 57%
Condominiums = 25%

Properties that would be interested in using reclaimed wastewater for irrigation if it were available at a lower cost than their present water supply:

Hotels = 71%
Condominiums = 64%

5B. Energy conservation

Energy-efficient lighting is widely used for a range of facilities at hotels and condominiums on Maui (Figure 6). Energy-efficient lighting is most commonly used for hallways. There is an opportunity for savings by increased use of energy-efficient lighting for all facilities.

5C. Buildings and maintenance

Most of the responding properties reporting that chemicals used for cleaning and maintenance were stored properly on a concrete base in an area protected from the wind, sun, and rain. Seventy one percent of hotels and 21% of condominiums said they have a written plan for disposal of chemical wastes. Potential problems identified were:

Disposing of vehicle wash water down storm drain:

Hotels = 13%
Condos = 50%
(Preferred disposal method is into a dry well or onto lawns)

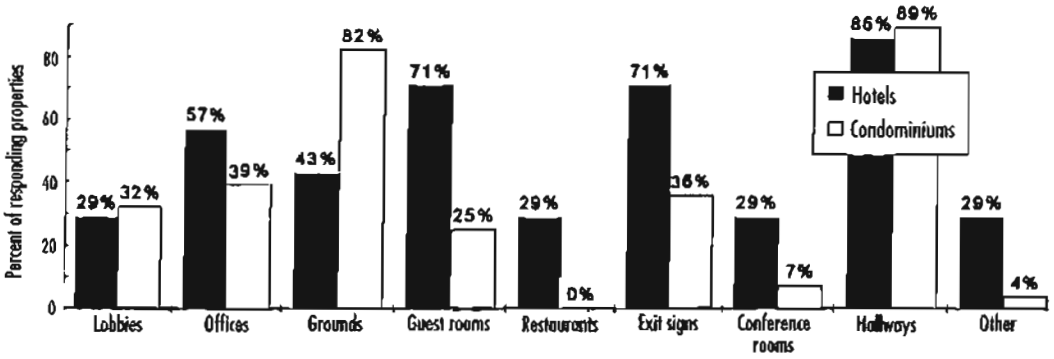


Figure 6. Use of energy-efficient lighting by hotels and condominiums on Maui.

Disposing of paint clean-up water down storm drain:

Condos = 8%

(Preferred disposal method is into the sanitary sewer or evaporation)

Disposing of swimming pool water into storm drains or directly into the ocean:

Hotels = 14%

Condos = 28%

(Preferred disposal method is dry well or onto lawn)

5D. Landscaping

The amount of fertilizer used per acre and type of fertilizers varied considerably among properties. Nitrogen use was more consistent and fell within the recommended rate of application for landscape application. There is potential for reducing the use of fertilizers with high phosphorus content. Regular applications of phosphorus are probably not necessary yet all properties except for one condominium reported using only fertilizers that contain from 3% to 30% phosphorus.

HOTELS AND CONDOMINIUMS CAN FURTHER REDUCE THEIR USE OF WATER, ELECTRICITY, AND FERTILIZERS.

The amount and types of pesticide use for landscaping also varied considerably among properties. Many of the properties (71% of hotels and 29% of condominiums) reported using integrated pest management, including introduction of natural predators or parasites, manual removal of insects, and use of pest resistant plants. There is potential for expanding the use of less harmful pesticides and promoting integrated pest management practices.

6. What policies, educational programs, and best management practices has government adopted to reduce pollutant inputs to the ocean?

The following list includes new activities since 1993 as well as the status of planned activities.

State of Hawaii

Hawaii's Coastal Nonpoint Pollution Control Program Management Plan, June 1996

Guidelines for the Treatment and Use of Reclaimed Water, November 1993

County of Maui

An ordinance on "Use of Reclaimed Water" was adopted as Chapter 20.30 of the Maui County Code.

Educational program promoting water conservation and wastewater reuse through

presentations in schools (Dept. of Public Works and Waste Management).

Drainage Rules have been adopted.

The West Maui Community Plan recommends development of a watershed protection overlay and protection of natural functions of drainageways.

The Sediment and Erosion Control (Grading) Ordinance is being revised to require that best management practices be used at construction sites to prevent construction runoff from polluting streams and coastal waters (Dept. of Public Works and Waste Management).

Training sessions in erosion control best management practices for the construction industry and for County inspectors are planned for 1997 (Dept. of Public Works and Waste Management).

Wellhead protection areas are delineated and a wellhead protection program is planned (Board of Water Supply).

Information on water conservation and water-efficient landscaping is provided to developers and businesses during the permitting process (Dept. of Water Supply)

Retrofit programs for toilets (Dept. of Public Works and Waste Management) and showerheads (Dept. of Water Supply) are underway.

A water-efficient landscaping ordinance is being drafted (Board of Water Supply).

Points of debate

Over the four year process of the West Maui Watershed Management Project there has been lively discussion and disagreement expressed among Advisory Committee members. This was certainly to be expected given the range of interests among committee members. When disagreement was evident, we sometimes referred to a model of consensus that uses 5 levels of agreement. These are:

1. Yes, unqualified
2. Yes, but...decision is acceptable
3. OK, I can live with it
4. OK, but...I can live with it but need to register a concern
5. No, do not agree, cannot live with

If everyone fell within the range of 1 to 3, i.e. everyone "can live with it," we considered that to be consensus. Remarkably, the findings and recommendations contained in the Owners Manual reflect consensus among Advisory Committee Members on a majority of points.

To provide an open accounting of our discussions, we make note of three areas where there continues to be debate among committee members. Letters from individual Advisory Committee members expressing a variety of points of view are included in Appendix D. These issues are:

1. Whether or not more research is needed on the plume from Lahaina's wastewater injection wells in order to determine if these injection wells are contributing to degradation of West Maui's Coastal Waters.

2. Whether or not enforceable regulatory programs are needed to adequately control nonpoint sources of nutrients, sediments, and pesticides associated with agricultural practices. See Community Comments and letters in Appendix D.

3. Whether or not existing data support the statement that "groundwater inputs, even if unaffected by man's activities (cesspools and fertilizers), may contain sufficient nutrients to support the amount of algal biomass in West Maui."

Hawaii's Coastal Nonpoint Pollution Control Program

Recommendations of the Owners Manual were developed in concert with Hawaii's

THE GOAL OF HAWAII'S 1996 COASTAL NONPOINT POLLUTION CONTROL PROGRAM IS TO PREVENT OR REDUCE POLLUTED RUNOFF FROM LAND.

Coastal Nonpoint Pollution Control Program (CNPCP).

In 1990, Congress modified the Coastal Zone Management Act by adding new requirements to protect coastal waters from polluted runoff and restore coastal water quality that has deteriorated because of nonpoint source pollution. These requirements respond to growing recognition across the U.S. that polluted runoff (nonpoint source pollution) is a significant source of pollutants discharged into coastal waters. These pollutants include soil, fertilizers, pesticides, herbicides, animal wastes, oil, grease, and litter. In Hawaii, the Office of State Planning and the Department of Health worked together to develop the Management Plan, released in June 1996. The Management Plan was conditionally approved by EPA and NOAA in 1997.

The Hawaii's Management Plan (1996) contains 56 *management measures* or goals that pertain to agriculture, forestry, urban areas, marinas and recreational boating, hydromodifications, and wetlands and riparian areas. The management measures are implemented through *best management practices,* which are defined as the most effective approaches using the best available and most cost-effective technology to prevent or minimize pollution that might result from a particular activity.

For example, a management measure for construction sites is to prepare and implement an approved erosion and sediment control plan prior to land disturbance. The management measure is implemented by a suite of best management practices designed specifically to minimize erosion at that site and may include silt fences, staged construction, protection of storm drain inlets, stabilizing of soil stockpiles, hydromulch, and other practices.

The management measures are based on technical and economic achievability rather than on cause-and-effect linkages between particular land use activities and particular water quality problems. Therefore, the Coastal Nonpoint Pollution Control Program is preventive rather than solely reactive.

The Watershed Owners Manual refers to management measures contained in the CNPCP Management Plan. The objectives and tasks of the Owners Manual constitute a local implementation plan, including best management practices customized for West Maui and designed to meet the management measures.

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CHAPTER 1

REDUCE SOIL EROSION THROUGHOUT THE WATERSHED

Watershed Objective 1: Reduce soil erosion throughout the watershed.

Objective 1A. Reduce soil erosion on agricultural land.

Objective 1B. Promote the use of sediment retention basins to prevent sediments from entering the ocean.

Objective 1C. Reduce soil erosion at construction sites.

Identification of the problem

Soil erosion is a naturally occurring process that is easily accelerated by human activities. The West Maui Watershed is a relatively high producer of sediment owing to its erodible soil conditions, steep slopes, and periodic heavy rainfall, especially at high elevations. Sediment particles are quickly transported to the ocean where increased turbidity after rain events is an aesthetic problem for the resort and ocean recreation industries. Suspended sediments are harmful to coral reefs when particles abrade and smother corals, and when turbidity reduces light intensity needed for photosynthesis by the symbiotic algae living within coral tissues. Sediments also transport chemical substances (pesticides, nitrogen, phosphorus) bound to eroded sediment particles. Dollar and DeCarlo (1997) demonstrated that release of nitrogen and phosphorus from sediment particles occurs relatively rapidly after contact with salt water, increasing nutrient loadings to coastal waters.

"Turbidity" is a measure of the amount of particles suspended in the water. The Hawaii Department of Health has established standards for acceptable levels of turbidity in coastal waters. In the nearshore waters of West Maui, the water quality standard for turbidity in open coastal waters is exceeded much of the time (see Fig. 3a and 3b). The volunteer coastal monitoring team has identified areas of persistent high turbidity or "turbidity hot spots" in West Maui. These include Kaopala, Kahana, Hanakaoʻo, Papakea, and S-turns (see Fig. 1 on page 8).

Soil erosion occurs in all of the major land uses within the watershed: forest, agriculture, and urban areas. Studies conducted by researchers in conjunction with the West Maui Watershed Project helped to (1) identify stages of the growing cycles for pineapple and sugar cane that are most susceptible to erosion and runoff and (2) better understand the relative contributions of these land uses to sediment and nutrient loads entering the ocean.

Stevenson's (1997) data on runoff from one monitoring site each in pineapple (4.5 acres), sugar cane (1.8 acres), forest (2,800 acres), and urban areas indicate the following general trends in nutrient and sediment concentrations (> means "greater than" and >> means "much greater than"):

RECENTLY PLANTED AGRICULTURAL FIELDS ARE MOST SUSCEPTIBLE TO EROSION. MATURE FIELDS HOLD SOILS IN PLACE.

Total Nitrogen	Pineapple, Sugar cane >> Forest, Urban
Ammonium	Pineapple >> Sugar cane, Forest, Urban
Nitrate	Pineapple >> Sugar cane >> Forest, Urban
Total Phosphorus	Sugar cane, Pineapple, Urban > Forest
Dissolved Phosphorus	Urban, Pineapple, Sugar cane >> Forest
Total Suspended Sediment	Sugar cane > Pineapple >> Forest, Urban

Visual observations, along with Stevenson's data, suggest that pineapple fields may generate the most runoff immediately before planting and for the first 8-12 months after planting, before the plant canopy cover is complete. This result may be related to the extent of impervious area covered by plastic mulch and the slope of the field (Fig. 7 and 8).

Sugar cane fields were found to be highly vulnerable to erosion and runoff for a period of roughly 4-6 months after being planted (Fig. 9). Following this time period, the canopy and root structures are fully developed. The mature sugar cane nearly eliminates runoff and is extremely protective of the soils. Cane roads are also susceptible to erosion.

Stevenson's (1997) rankings apply only to concentrations of nutrients and sediments in runoff samples; he did not attempt to calculate the total quantity or loads generated by these land uses. Soicher and Peterson (1996) estimated the total loadings (rate of input) of suspended sediments and nitrogen entering the ocean from three streams during a 1994-5 study, a period of unusually low rainfall. Samples collected from above and below agricultural fields in the Honokowai Stream indicate that approximately two thirds of the suspended sediment and half of the nitrogen loads come from agricultural land. Forested land is the other major source of these materials.

To reduce the amount of sediments entering the ocean from the West Maui Watershed, erosion controls should be emphasized on agricultural and forested land. These controls can include best management practices (BMPs) to keep soils in place, and sediment retention basins to trap sediments on land before they

Figure 7. Wesley Nohara demonstrates for the West Maui Watershed Advisory Committee how deep plowed fallow pineapple fields act like giant sponges, absorbing large quantities of water without significant soil loss.

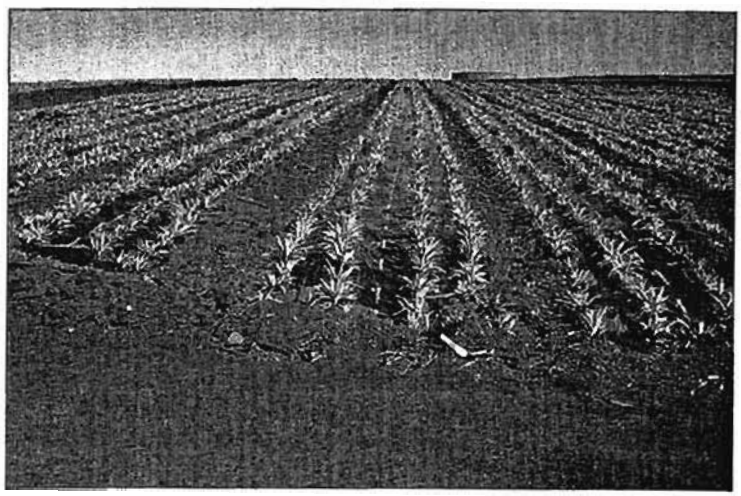

Figure 8. Newly planted pineapple fields were identified as vulnerable to runoff and erosion. Plastic mulch, used as part of integrated pest management, reduces the amount of soil surface that is available to absorb water.

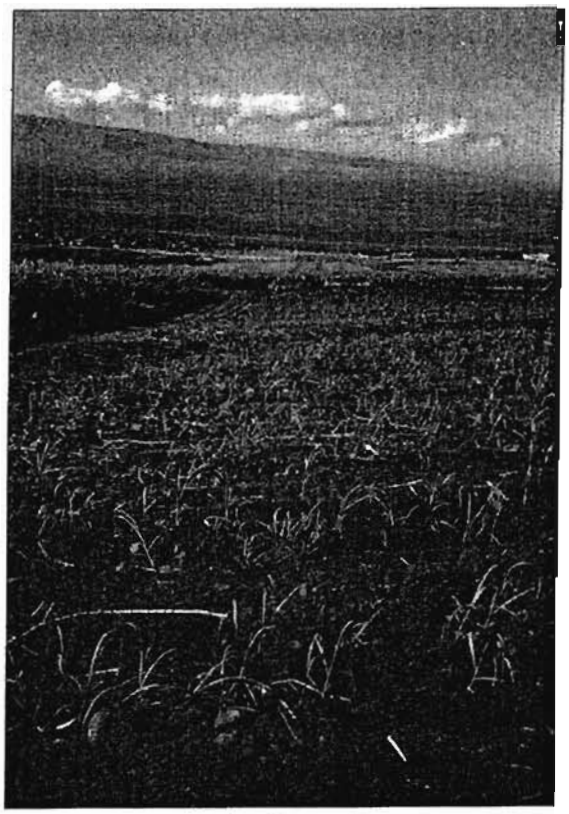

Figure 9. Newly planted sugar cane fields are the stage of growth most vulnerable to erosion.

reach the ocean. Preventing erosion is generally preferable to trapping suspended sediments.

Some sites in urban areas are also susceptible to erosion, particularly construction sites and roadsides. Since the major sediment retention basins are mauka of urban areas, urban runoff is transported directly to the ocean through streams and storm drains lacking structural BMPs to remove pollutants. Construction sites can be a significant source of sediments in runoff entering coastal waters because of West Maui's fine grained soils and the proximity of new development to the ocean.

Management of construction sites and urban runoff will be a growing concern as the resident population of West Maui is projected to increase from 14,600 (1990 census) to 21,000-22,600 by 2010. During the same period, the visitor population is expected to increase from 20,000 to 32,000-37,700.

What's being done to control agricultural erosion?

At present, there are several efforts in place to minimize erosion and sediment transport to the ocean. These include the use of many in-field BMPs, as recommended and designed by the Natural Resources Conservation Service (NRCS). These soil conservation plans are required by the Food Security Act for sugar cane fields on highly erodible lands. Soil conservation plans are approved by the West Maui Soil and Water Conservation District (WMSWCD).

Maui Pineapple Company, in partnership with the West Maui Soil and Water Conservation District (WMSWCD), applied for and received an EPA Nonpoint Source Control Demonstration Grant to identify erosion problems in the fields and install new BMPs to control erosion in these areas. This work was completed in 1996. A second grant for erosion control improvements in the Honolua Stream drainage was approved for funding and work began during the summer of 1997.

A workshop in May 1997 brought together local and statewide agricultural experts to exchange ideas for improving erosion control and nutrient management in West Maui (Fig. 10). A list of recommendations from the workshop is included in Appendix E.

The WMSWCD and County of Maui, in partnership with NRCS, have obtained federal funding through the Honolua Watershed Project to construct a series of sediment retention basins in West Maui. Large sediment retention basins are presently in place on Napili 2-3, Napili 4-5, Pohakukaanapali, Kahana, Mahinahina, and Honokowai Streams. Two new basins at Honokeana and Kaopala streams are being constructed in 1997. The Lahaina Watershed Project includes plans for

additional sediment retention basins south of Kahoma Stream. This project is presently in the design phase. Construction is subject to funding availability.

The large quantities of sediments trapped by the basins demonstrate their value (see Table 4). In Towill's 1996 study of the sediment retention basin in Honokowai Stream, 75-90% of the suspended sediment was trapped by the dam for two small storms of return frequency < 1 year.[3] Sediment retention basins are most effective in small rainfall events where all of the stream flow is retained in the basin. In larger storms, the basins reduce the peak rate of stream flow and trap coarser sediment particles and debris. The water retention time for large storms is not sufficient to settle fine sediment particles; water reaching the ocean will characteristically be colored red or brown by the silt that remains suspended.

The "Stormwater and Drainage Management Plan for West Maui" (Woodward-Clyde Consultants, 1996) was developed by the West Maui Watershed Project to recommend cost-effective, reliable, and sustainable control measures to reduce pollutants in urban runoff, particularly nutrients and sediments. This Plan reinforces the importance of constructing new sediment retention basins in West Maui (single large basins and smaller basins in series), and the need to regularly clean existing basins to maintain their efficiency for trapping sediments. The County of Maui is responsible for removing accumulated sediments from the large desilting basins at Napili 4-5, Kahana, Mahinahina, Honokowai, and Kahoma Streams. The remaining sediment retention basins are maintained by Maui Pineapple Company and Kapalua Land Company. Most basins were cleaned of accumulated sediments in 1995 or 1996.

Figure 10. Agricultural experts tour fields and exchange ideas at May 1997 workshop sponsored by the West Maui Watershed Management Project. Kimo Falconer describes terraces used for erosion control in sugar cane fields.

What's being done to control erosion from construction sites?

Construction and development within the watershed contribute sediments and pollutants to storm water runoff during the grading and construction phase. After construction is completed, increased volume and peak rates of runoff flow from paved surfaces mobilize and transport pollutants such as nutrients from landscape fertilizers, pesticides, herbicides, pet wastes, particulates from brake and tire wear, and household hazardous wastes (e.g., used motor oil, paints, solvents). Recommendations for the control of post-construction runoff and for the design of new drainage structures are discussed in Chapter 4.

Maui County's grading ordinance is intended to prevent flooding and protect property and public welfare by controlling grubbing and grading operations. The County and the Soil and Water Conservation Districts have authority to enforce the County ordinance. Separate permits are required for grading and grubbing. Developers

[3] Refers to a size of storm where the amount of rainfall is likely to occur again in less than one year.

CONSTRUCTION SITES SHOULD CONTROL RUNOFF AND RETAIN SOIL ON SITE BY USING A VARIETY OF BEST MANAGEMENT PRACTICES FOR EROSION CONTROL.

of projects disturbing one acre or more, or that involve cut or fill slopes greater than 15 feet in height, must develop a drainage and erosion control plan that includes erosion control measures (e.g. sedimentation basins, erosion control planting, mulching, berms, etc.), and analyses of soil loss.

The present grading ordinance does not specifically state the intention to protect water quality from runoff of pollutants at construction sites. Maui County's Department of Public Works and Waste Management is revising the grading ordinance to better address environmental concerns, including but not limited to water quality. The revisions are intended to meet the 1990 Coastal Zone Act Reauthorization Amendments, Section 6217 Best Management Practices, as described in Hawaii's Coastal Nonpoint Pollution Control Program Management Plan. The County received a Nonpoint Source Control Grant, awarded by the Department of Health, under section 319(h) of the Clean Water Act, for revising the grading ordinance and providing training for inspectors and the development community. The revisions are expected to be adopted in 1997.

In addition to Maui County requirements, since 1991 all developments resulting in the disturbance of five acres or more (or that are part of a common plan that will eventually disturb five acres or more) are required to obtain coverage under an NPDES General Construction Activities Storm Water Permit. This permit, which is issued by the Hawaii Department of Health, requires the implementation of a Storm Water Pollution Control Plan to control erosion, sedimentation, and other pollutants (from vehicles, construction materials, and wastes) in stormwater runoff from the site.

The "Stormwater and Drainage Management Plan for West Maui" (Woodward-Clyde, Consultants 1996) describes specific best management practices for erosion and sediment control and waste management at construction sites. Because of the fine grained nature of local soils, this plan emphasizes the need to use best management practices at construction sites to keep soil in place rather than rely on trapping sediments downstream (Figure 11). The objective is to retain all soil on site.

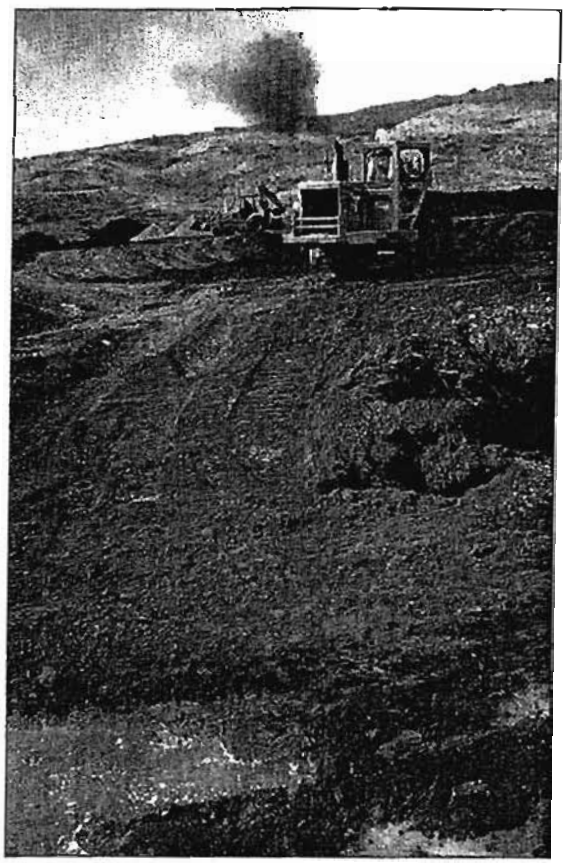

Figure 11. Construction sites expose large areas of bare soil that are highly susceptible to runoff and erosion unless appropriate best management practices are used to retain runoff and soil on site.

Objective 1A. Reduce soil erosion on agricultural land

Coastal Zone Management Measures:[4]

- *Apply any combination of conservation practices and management that achieves an cceptable level of treatment to minimize the delivery of sediment from agricultural lands to surface waters, or*
- *Design and install a combination of management and physical practices to settle the settleable solids and associated pollutants in runoff delivered from the contributing area for storms of up to and including a 10-year, 24-hour frequency.*

Management measures are to be implemented as part of a non-regulatory Agricultural Pollution Prevention Plan.

Tasks to reduce soil erosion on agricultural land and construction sites

This section was developed as a group by the West Maui Watershed Project's Agriculture Advisory Group, including Janet Ashman, Eve Clute, Neal Fujiwara, Kimo Falconer, Herve Fleisch, Don Gerbig, Wil Leon Guerrero, Wes Nohara, Glenn Shepherd, and Marty Stevenson. The most effective combination of BMPs and maintenance efforts will be specific to particular crops and field sites. Not every task or BMP will be appropriate for every site. See Appendix A for acronyms and abbreviations of agencies, organizations, and companies responsible for implementation.

TASK 1. Continue and expand the application of standard erosion control BMPs in combination. Site conditions dictate the appropriate combination of practices, including as options: (MPC, NRCS, PMC)

Diversions and terraces to intercept sheet flow and direct runoff at low velocity to a sediment retention basin or to natural waterways. Designed for 10-year, 24-hour storms.

Contour farming and/or cross block layout to reduce sheet and rill erosion. Where contour farming is practical, apply as the most effective BMP for reducing soil loss from sloping fields.

Chiseling, subsoiling, and deep plowing to increase water holding capacity. Best if done cross slope.

Crop residue use to stabilize surface. When incorporated into soil, residues also recycle nutrients and improve soil texture.

FIVE ACTIONS TO REDUCE EROSION FROM AGRICULTURAL FIELDS

1. **Expand the use of proven erosion control BMPs and develop and test new BMPs with emphasis on roads, newly planted fields, and areas upland of high turbidity waters.**
2. **Improve the maintenance of BMPs.**
3. **Expand the use of sediment retention basins in waterways by constructing new basins at Hahakea and Kahoma, and by increasing the capacity or number of basins in other streams.**
4. **Clean and maintain sediment retention basins regularly.**
5. **Develop Pollution Prevention Plans for pineapple, sugar & coffee.**

[4] The management measure is quoted directly from *Hawaii's Coastal Nonpoint Pollution Control Program Management Plan Volume 1.* See Introduction to Watershed Owners Manual for an explanation of the Coastal Nonpoint Program and management measures.

Field wind breaks as dust barrier for residences, roads, and ocean. Increase use of fast growing, drought-resistant trees or bushes in single or double rows (e.g. Casaurina and Oleander).

Grassed waterways to slow water velocities on steep slopes. Increasing their use, particularly along steep roadways, is recommended. The type of grass chosen should be adapted to site conditions.

Harvest sugar cane and plant fields when rainfall is less likely.

Cinders or gravel on steep road sections help to stabilize surface and reduce erosion, and should be used where practical.

Side drains to direct water off roads and into natural waterways at frequent intervals to prevent buildup of erosive quantities and velocities of water.

TASK 2. Improve the maintenance of erosion control BMPs. (MPC, NRCS, PMC)

Schedule NRCS inspection with the plantation superintendent to identify vulnerable areas and set priorities for maintenance. Inspections before and during the rainy season will help to identify problem sites and needed repairs. Focus attention primarily on roads, newly planted fields, and other vulnerable areas.

Provide training and education for equipment operators so they understand and appreciate the design and maintenance of erosion control BMPs.

Complete maintenance before the rainy season whenever possible. Make repairs during the rainy season when conditions allow.

Field maintenance to include: assurance of integrity of diversions and terraces by building up berms and removing sediments from channels, removal of grasses that block outlets; filling in ruts; reshaping and reseeding grassed waterways; and removing sediments from sediment retention basins.

Road maintenance to include building up terraces, removing sediments from side drains, filling in ruts, applying gravel.

TASK 3. Promote the development and testing of new erosion control BMPs to reduce erosion in areas of high runoff volumes, including roads and fields planted within the last 12 months. (DOH, MPC, PMC, NRCS, WMWMP, UH)

Consult with erosion control experts from the University of Hawaii, Agricultural Extension Service, and NRCS to brainstorm potential new BMPs that may be effective in West Maui. (See recommendations from workshop in Appendix E.)

Test new BMPs to reduce runoff generated from plastic mulch in newly planted pineapple fields to determine their effectiveness and practicality, e.g.:

- Revise field layouts and block them more in line with contours .
- Use cross ditches to break flow along sheets of mulch.
- In steep areas, plant pineapple crowns between sheets of mulch to break the flow of water.
- Use pineapple residue as mulch between sheets of plastic.
- When laying mulch, furrow along the planting line so that water flows toward plants.
- Intercropping. Plant another crop at the end of pine blocks to intercept water flow.
- Deep rip troughs of diversions.
- Plant vegetation (e.g. Sudex) on diversions/terraces.

Reduce runoff from fallow or newly planted cane fields.

- Plant parallel to terraces instead of across terraces.
- Install temporary terraces, basins and ditches in fallow or abandoned fields.
- Increase the size or frequency of terraces to better account for planting across terraces and for road grading.

Reduce runoff from areas between rows of coffee plants.

- Rip the interrows periodically to improve infiltration.
- Use permanent perennial cover crops between rows (e.g. oats, burr clover) to hold soil.

Reduce erosion on roads.

- Establish vegetated filters along edges of fields and roads. Best if multispecies, multilayer vegetation.
- Establish a groundcover for road sides (e.g. vetirer grass).
- Use closely spaced water bars in roads to break flow and divert water into fields or filter strips.
- Use soil polymers to bind soils for steep road segments.

TASK 4. Develop vegetative buffers between fields and streams. (NRCS, WMSWCD)

Identify vegetative cover, including native and non-invasive species, for planting in vegetative corridors along edges of fields.

Restore riparian vegetation along stream banks.

Establish permanent grassed waterways.

Establish permanent rows of plants to act as a "bioterrace."

Establish filter strips in the gulches and drainages using star grass or California grass.

TASK 5. Develop non-regulatory Pollution Prevention Plans (PPPs) specific to West Maui for pineapple, sugar and coffee agriculture. (MPC, PMC, WMSWCD)

These plans are expected to be required for compliance with Hawaii's Coastal Non-point Pollution Control Program. PPPs will include BMPs for erosion control, nutrient, pesticide, and irrigation water management practices, and will be developed with assistance from WMSWCD.

Track the implementation of PPPs.

TASK 6. Target drainage basins upland from shoreline "high turbidity areas" for aggressive erosion control. (MPC, NRCS, PMC, WMSWCD, WMWMP)

Priority areas for implementation, inspection and maintenance of BMPs, based on turbidity monitoring, are Kahana, Kaopala, Hahakea, and Pohakukaanapali.

Test and develop new BMPs such as those suggested in Tasks 3 and 4.

Objective 1B. Promote the use of sediment retention basins to prevent sediments from entering the ocean.

TASK 1. Construct new large sediment retention basins in the following major streams: Hahakea and Kahoma. (COE, MC, NRCS, PMC, WMSWCD)

After construction is completed, evaluate the effectiveness and efficiency of basins for removing sediment and nutrients.

TASK 2. Evaluate the feasibility of expanding the capacity for sediment retention by (1) the addition of smaller, low-cost basins in series or (2) deepening existing basins.

The highest priority for expanding capacity are Kahana and Napili 4-5 basins because of their small size relative to the drainage area. Napili 2-3 may also be undersized,

but the series of basins within the drainage partially compensates for the small capacity of the major basin.

Request that NRCS evaluate the potential of deepening or widening basins without impairing the structural integrity of the dams.

Request that NRCS evaluate the potential for constructing sediment and water retention systems at high elevation where water can be diverted for irrigation.

Request that Maui County direct contractors to potential excavation sites in exchange for free soil.

TASK 3. Assure regular cleaning and maintenance of sediment retention basins.

Remove sediments following major rain events, or as needed. Link sediment removal with local construction projects to reduce transportation costs or return soil to agricultural fields. Evaluate feasibility of temporary storage for excavated soil near basins. (MC, MPC)

Each year WMSWCD will evaluate the need for cleaning and maintenance of basins and notify Maui County Department of Public Works and Waste Management in the spring of cleaning needs.

TASK 4. Evaluate potential for improving erosion control and sediment trapping within stream beds using vegetation and stream geomorphology. (WMWMP)

Consult with experts in stream geomorphology and function to recommend modifications to improve in-steam erosion control and sediment trapping. (WMWMP)

Evaluate feasibility of establishing artificial wetlands or taro lo'i in conjunction with a series of basins to filter fine particles and remove nutrients.

Develop engineering designs to provide flood protection and sediment retention as alternative to widely used system of concrete channels and dams. (MC)

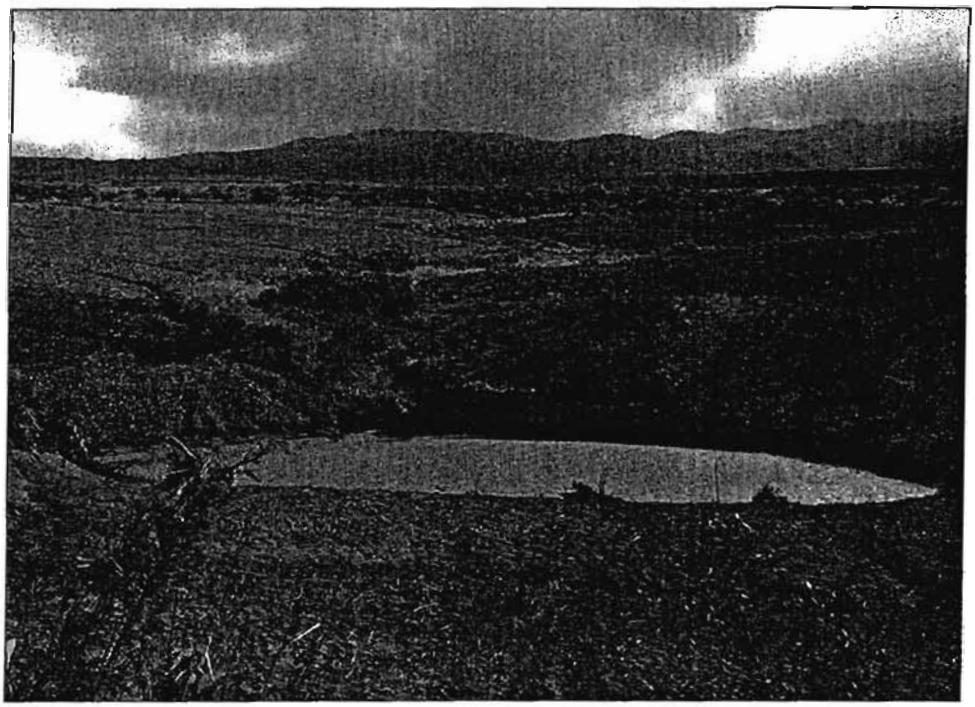

Figure 12. This pond is a sediment retention basin at the makai end of pineapple fields. The basin traps water, allowing much of the suspended sediment to settle to the bottom. Note "delta" of settled sediments in center of picture.

TASK 5. Monitor the effectiveness of erosion control BMPs by tracking improvements in coastal water quality. (DOH, WMWMP)

Continue volunteer coastal monitoring project's turbidity monitoring program for West Maui. Track changes in turbidity patterns as new sediment retention basins are completed.

Use revised Dept. of Health water quality monitoring program to track and assess health of coastal waters in West Maui.

Objective 1C. Reduce soil erosion at construction sites

Coastal Zone Management Measures:[5]

A. Construction Site Erosion and Sediment Control Management Measure

(1) Reduce erosion and, to the extent practicable, retain sediment onsite during and after construction, and

(2) Prior to land disturbance, prepare and implement an approved erosion and sediment control plan or similar administrative document that contains erosion and sediment control provisions.

B. Construction Site Chemical Control Management Measure

(1) Limit application, generation, and migration of toxic substances,

(2) Ensure the proper storage and disposal of toxic materials, and

(3) Apply nutrients at rates necessary to establish and maintain vegetation without causing significant nutrient runoff to surface waters.

TASK 1. Adopt revisions to Maui's Soil Erosion and Sedimentation Control Ordinance (Chapter 20.08) to provide a comprehensive framework for requiring the control of sediments and other pollutants in runoff from construction sites. Include the following provisions: (Maui County-Dept. of Public Works & Waste Management)

Protecting water quality and preserving natural environment are stated goals.

All grading, grubbing, and stockpiling operations are subject to minimum best management practices designed to prevent damage by sedimentation to streams, water bodies, natural areas, and property of others. No exemptions for single family homes.

Proper storage of construction materials and proper disposal of wastes is required.

Sites exceeding one acre or where proposed cut or fill is greater than 15 ft. in height require an Erosion Control Plan and a Drainage Plan and Report, including but not limited to drawings and reports showing locations of best management practices and disposal of runoff water. Erosion Control and Drainage Plans must be available on site.

Increase penalties for violation of grading ordinance and provide penalty provisions for grading without a permit.

For large construction projects, bonds are required and may be retained, in part, for 6 months after completion of construction to ensure that soil has been adequately stabilized.

[5] The management measure is quoted directly from *Hawaii's Coastal Nonpoint Pollution Control Program Management Plan Volume 1.* See Introduction to Watershed Owners Manual for an explanation of the Coastal Nonpoint Program and management measures.

RECOMMENDED EROSION AND SEDIMENT CONTROLS AT CONSTRUCTION SITES[6]

- Erosion control plan available on site (for projects over one acre in area or where cut or fill will exceed 15 ft. in height).
- Schedule clearing and grading during dry season to the extent practicable.
- Stage grading to limit the total area of exposed soil at any one time (WMSWCD recommends maximum of 15 acres open at any time).
- Preserve natural vegetation and protect with fencing or tree armoring.
- Locate potential nonpoint pollutant sources away from steep slopes and sensitive areas such as streams.
- Stockpile topsoil and chipped vegetation to reapply to areas needing revegetation.
- Cover stockpiles to prevent wind and water erosion.
- Use dust suppression measures at all times on all exposed areas.
- Intercept runoff above disturbed areas and convey it to a stabilized channel or storm drain.
- On long or steep slopes, construct terraces, benches or ditches at regular intervals to intercept runoff. Roughen slopes to slow overland flow velocities.
- Provide linings (grass, rocks, geotextiles) for runoff conveyance channels to prevent erosion.
- Use checkdams to stabilize channel gradients and slow runoff.
- Seed with quick growing grass such as Bermuda grass, fertilize, and irrigate disturbed areas within 2 weeks after the last disturbance.
- Use hydraulic mulches or matrices to provide temporary erosion control on slopes until vegetation is established.
- Use bonded fiber matrices, erosion control blankets, or geotextiles on critical, steep slopes as temporary erosion control until vegetation is established.
- Protect storm drain inlets to prevent sediment from running offsite.
- Use gravel construction entrances to prevent tracking of sediments onto roads.
- Provide BMPs (detention basins, filter fabric silt fences, straw bales, sand bags, vegetated filter strips) to capture sediment that is transported in runoff to prevent the sediment from leaving the site.
- Temporary brush or rock filters in gullies to slow flow velocities and remove sediment from concentrated flow.

[6] Recommendations adapted from language in proposed revisions to Maui County Soil Erosion and Sedimentation Control Ordinance (Chapter 20.08).

TASK 2. Provide a comprehensive training program for County inspectors, Soil and Water Conservation Districts, and the development community. Training to include: (Maui County Dept. of Public Works & Waste Management)

County and State requirements for erosion control.

Selection of appropriate erosion control best management practices, based on performance.

Proper installation and maintenance of best management practices.

Example of a good erosion control site plan.

Demonstration site to display proper use of BMPs.

TASK 3. Develop a manual of BMPs for erosion control at construction sites, specifically designed for local conditions in Hawaii. Manual to include: (Maui County Dept. of Public Works and Waste Management)

Descriptions of BMPs including design, cost, effective uses.

Proper installation and maintenance of BMPs.

Example of a good Erosion Control Plan and a Drainage Plan and Report.

Hazardous waste minimization and pollution prevention.

TASK 4. Improve inspection and enforcement of County and State requirements for erosion control. (DOH, DOT, MC Dept. of Public Works & Waste Management)

Make it easy to register a complaint by providing a central phone number, listed in the phone book. Respond to complaints within 3 days and notify person filing complaint of findings and actions taken.

Inspect all major permitted construction sites for compliance with erosion control site plan at least once during construction, in rainy season if possible.

Where clear violations result in public complaints and environmental damage, take aggressive enforcement action and in strategic cases, issue a press release announcing penalties.

Hold informal meeting between County and State inspectors to discuss their roles and enhance cordial working relationships. Exchange information about complaints and inspections among State, Federal, County inspectors and the Soil and Water Conservation Districts. Schedule joint inspections where possible and share follow-up responsibilities where that may be efficient.

Evaluate potential for giving County inspectors authority to issue citations with penalties (like traffic tickets) on site for clear violations of grading permits.

TASK 5. Develop a clear, simple brochure describing the revised grading ordinance and how to apply for a grading/grubbing permit. (MC Dept. Public Works & Waste Management)

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Table 6. Implementation responsibilities for reducing soil erosion.

COE U.S. Army Corps of Engineers
DOH Hawaii State Dept. of Health
MC Maui County
MPC Maui Pineapple Company
PMC Pioneer Mill Company
UH University of Hawaii
WMSWCD West Maui Soil and Water Conservation District
WMWMP West Maui Watershed Management Project

	ACOE	DOH	MC	MPC	NRCS	PMC	UH	WMSWCD	WMWMP
Objective 1A: Reduce soil erosion on agricultural land.									
Task 1. Continue and expand use of erosion control BMPs.				✓	✓	✓			
Task 2. Maintain erosion control BMPs.				✓	✓	✓			
Task 3. Promote the development and testing of new erosion control BMPs.		✓		✓	✓	✓	✓		✓
Task 4. Develop vegetative buffers between fields and streams.					✓			✓	
Task 5. Develop non-regulatory Pollution Prevention Plans for pineapple, sugar and coffee.				✓		✓		✓	
Task 6. Target drainage basins upland from "turbidity hot spots" for aggressive erosion control.				✓	✓	✓		✓	✓
Objective 1B: Promote the use of sediment retention basins.									
Task 1. Construct new large sediment retention basins at Honokeana, Kaopala, Kahoma.	✓		✓	✓	✓			✓	
Task 2. Evaluate the feasibility of expanding capacity of existing sediment retention basins.			✓		✓			✓	
Task 3. Assure regular cleaning and maintenance of sediment retention basins.			✓	✓				✓	
Objective 1C: Reduce soil erosion at construction sites.									
Task 1. Adopt revisions to Maui County's Grading Ordinance.			✓		✓			✓	✓
Task 2. Training program for inspectors and developers.		✓	✓		✓			✓	
Task 3. Develop BMP manual for construction sites.			✓		✓				
Task 4. Improve inspection and enforcement of County & State requirements.		✓	✓					✓	
Task 5. Develop a simple brochure describing new grading ordinance.			✓						

CHAPTER 2

PROMOTE POLLUTION PREVENTION AND WASTE MINIMIZATION FOR FERTILIZERS & TOXIC POLLUTANTS

Watershed Objective 2: Promote pollution prevention and waste minimization for fertilizers and toxic pollutants.

Objective 2A. Promote pollution prevention for homes and businesses.

Objective 2B. Promote pollution prevention for boats.

What is pollution prevention?

Cleaning up pollution, whether it's in the ocean, groundwater, or your backyard, is difficult and costly. A common-sense approach to caring for your home, yard, garden, vehicles, and waste can prevent many kinds of problems that involve pollution. Pollution prevention involves buying and using products that are less toxic and generate less waste products. It involves using just the right amount of cleaning products, fertilizers and chemicals without waste. It is related to how and where you wash your car, clean your painting supplies, and dispose of waste.

Pollution prevention is important for large scale commercial operations like agriculture and hotels, and also for individual homes and small businesses. Hawaii's Coastal Nonpoint Pollution Control Program requires the development of non-regulatory pollution prevention plans for agriculture, covering erosion control, fertilizer and chemical use, and irrigation practices, and for marinas (see management measures below). These plans should be developed and implemented within the next few years.

Following common-sense practices to reduce pollution will save you money. Water and energy conservation, reusing, recycling, buying less toxic products, preventing runoff, proper storage of chemicals, and minimizing waste are all actions that prevent pollution. Preventing pollution will likely be safer for you, your family, neighbors, and pets as well as the environment.

More efficient use of fertilizers for landscaping is an area where pollution prevention can make a difference on Maui. Studies in West Maui found high concentrations of phosphate, a nutrient that is essential to the growth of algae in coastal waters, in runoff from streets. The source of the phosphate is probably landscape fertilizers. Runoff of fertilizers can be prevented by using simple best management practices such as (1) testing soils to determine what nutrients are needed, (2) applying slow release fertilizers, (3) avoiding fertilizer use near storm drains, drainageways, and the shoreline, and (4) not fertilizing when rain is forecast.

What's being done to prevent pollution on Maui?

"Island Stewardship: A Guide to Preventing Water Pollution for Maui's Homes and Businesses" is a booklet that contains over 100 suggestions of common-sense actions to protect our water resources. It discusses water conservation, runoff, landscaping,

PREVENTING POLLUTION IS MUCH EASIER THAN CLEANING IT UP!

erosion control, pesticide use, car maintenance, wastewater problems, and the use and disposal of household chemicals.

Maui County has a recycling program and is avidly promoting the development and production of products made on Maui from recycled materials. Goods that can be recycled on Maui currently include aerosol cans, aluminum cans and foil, auto batteries, cardboard, glass, home yard trimmings, metal cans, motor oil, newspaper, plastic, and tires. For the latest information on how and where to recycle on Maui, call the Recycle Maui County Hot Line at 243-7880. The Hot Line also provides information on composting and compost products, disposal and recycling of large appliances, and disposal of paints and other hazardous materials.

Maui participates in a statewide exchange network for hazardous materials, HIMEX Hawaii Materials Exchange. HIMEX helps to reduce waste and cost by matching up businesses and individuals who have excess materials such as agricultural chemicals, pesticides, herbicides, and paints with potential users. Anyone can advertise products for trade on the HIMEX computer database and newsletter. For more information, call 667-7744 or statewide call 888-991-4000. The website is http://maui.net/~mrghimex.

"Landscape Management Guidelines" (Landscape Industry Council of Hawaii, 1996)[7] is a guide to quality landscape management that will help to ensure that both the landscape and the environment are cared for properly. It is designed for the landscape industry and for property managers who prepare specifications for landscape maintenance services. The Landscape Industry Council and the Cooperative Extension Service also offer training courses on landscape fertilizer use and other aspects of landscape management.

The West Maui Watershed Project has targeted hotels and condominiums for a pollution prevention training and assistance program. A survey of hotels and condos regarding their water and energy use, landscaping practices, buildings and maintenance practices was conducted in summer 1997. These findings are being used to design an educational program for Maui's resort properties. The focus will be on preventing water pollution through landscaping practices, pest control, chemical storage and disposal, and vehicle maintenance. Participation in the program will be voluntary. A "clean water" certification will be awarded to qualifying properties as an incentive to participate. This certification can be used in promoting the property in today's market of environmentally concerned visitors. For information on the pollution prevention program for Maui's hotels and condominiums, contact Dr. June Harrigan at Hawaii Department of Health in Honolulu (phone 808-586-4337).

Figure 13. This man is applying fertilizer at a waterfront condominium during a rainstorm. To avoid fertilizer runoff, never apply fertilizer before or during a rainstorm.

[7] Available from Landscape Industry Council of Hawaii c/o David Hensley, UH Horticulture, 3190 Maile Way, Honolulu, HI 96822.

Objective 2A. Promote pollution prevention for homes and businesses

VI. Pollution Prevention[8]

A. Pollution Prevention Management Measure.

Implement pollution prevention and education programs to reduce nonpoint source pollutants generated from the following activities, where applicable:

(a) The improper storage, use, and disposal of household hazardous chemicals, including automobile fluids, pesticides, paints, solvents, etc.;

(b) Lawn and garden activities, including the application and disposal of lawn and garden care products, and the improper disposal of leaves and yard trimmings;

(c) Turf management on golf courses, parks, and recreational areas;

(d) Improper operation and maintenance of onsite disposal systems;

(e) Discharge of pollutants into storm drains including floatables, waste oil, and litter;

(f) Commercial activities including parking lots, gas stations, and other entities not under NPDES purview; and

(g) Improper disposal of pet excrement.

Tasks to prevent pollution from homes and businesses

Task 1. Develop a public education program for homes and businesses, based on recommendations in the booklet "Island Stewardship: Guide to Preventing Water Pollution for Maui's Homes and Businesses." (WMWMP, Hawaiian Islands Humpback Whale National Marine Sanctuary, Board of Water Supply)

Develop an educational video for Akaku and classroom use.

Make information available via Internet.

Develop school curricula to educate kids about what they can do to prevent water pollution. Train teachers to use the curricula.

Establish a group of volunteer trainers to bring information about pollution prevention into schools and send information home with kids, who will teach their families.

Do programs for "Knife and Fork Clubs" to outreach to business community about pollution prevention.

Task 2. Develop a household hazardous waste disposal and educational program for Maui County. (Maui Co. Dept. of Public Works and Waste Management)

Develop an educational program on safe disposal of household hazardous waste.

Develop a drop-off program for paints, pesticides and other hazardous wastes.

Task 3. Develop a pollution prevention training and certification program for Maui's hotels, condos, golf courses, and landscapers. (WMWMP)

Award contract for training and certification program with emphasis on landscaping, pest control, outdoor storage, cleaning and maintenance.

Design and implement an incentive program to encourage properties to implement pollution prevention practices. Look to MECO's programs for solar panels and shower heads as models.

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[8] The management measure is quoted directly from *Hawaii's Coastal Nonpoint Pollution Control Program Management Plan Volume 1*. See Introduction to Watershed Owners Manual for an explanation of the Coastal Nonpoint Program and management measures.

Task 4. Continue to improve the use and efficiency of best management practices for agricultural fertilizers and pesticides, as part of agricultural pollution prevention plans. (NRCS, MPC, PMC, WMSWCD)

Develop precision agriculture to ensure careful application of fertilizer and pesticides based on local soil/crop needs.

Task 5. Expand educational efforts for landscape industry on improving efficiency of fertilizer and pesticide use. (UH Extension Service, Landscape Industry Council)

Task 6. Consider the feasibility of instituting a "leash law" for the urban areas of Maui County. (Maui County)

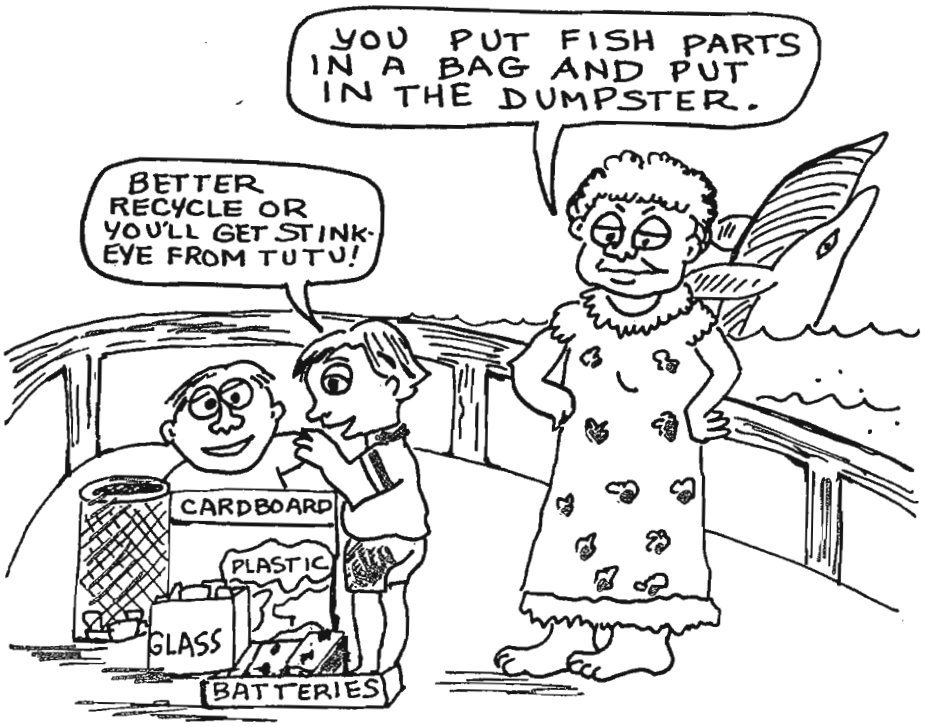
Task 7. Develop an educational program for Maui's businesses on stormwater pollution prevention. (Maui County Dept. of Public Works and Waste Management)

Objective 2B. Promote pollution prevention for boats

Identification of problem

The coastal waters of Maui are known for their clarity, humpback whales, unique reefs, turtles, fish and productive sport fishing. Yet, increasingly, we hear about signs of degradation . . . nuisance algal blooms, plumes of mud, turtles with tumors, floating feces, and dying corals. Indeed, studies suggest that heavy human use is harming our reefs and fish communities at popular dive sites on Maui (Brown and Forestell, 1995).

A large local marine recreation industry depends on the resources of Maui's coastal waters. As the signs of degradation become more apparent, it becomes essential for each boater to follow the best possible environmental practices in using and maintaining boats. While the effect of a single boat may seem insignificant, multiply this by the hundreds of boats that use Lahaina Harbor and Mala Wharf over the year and such effects become apparent.



What's being done to control pollution from boats?

A recycling facility is being built at Lahaina Harbor. There will be drop off containers for aluminum, plastic, cardboard and paper. These will be accessible to both Harbor users and King Kamehameha III School. This project is spearheaded by Tim Burke of Atlantis Submarines with support from local businesses including Atlantis Submarines, Club Lanai, Windjammer, Lahaina Yacht Club, and Pacific Whale Foundation.

A Coast Guard trailer equipped with oil spill clean-up materials is located at Lahaina Harbor. The

equipment is available for use in the case of an oil or hazardous material spill. The Harbor Agent, Fire Department, and Coast Guard Station at Maalaea have keys. In the case of emergency, the padlock can be broken to gain access to the supplies. If a spill can be attributed to a specific boat or source, that party is responsible for the entire cost of the cleanup, including the replacement of equipment. Local volunteers have been trained in the use of this equipment.

In terms of protecting water quality, the most important factor in the daily operation of boats is compliance with marine toilet rules. Human waste contains bacteria and viruses that carry disease and nutrients that help algae grow. The U.S. Coast Guard is responsible for enforcing equipment requirements for marine sanitation devices. The Hawaii Department of Health takes enforcement action for illegal discharges to marine waters.

From an environmental and health perspective, the very best way to dispose of sewage from boats is to use the pump-out station located on the north side of the dock in Lahaina Harbor (Figure 15). The wastewater is piped from the Harbor to the Lahaina Wastewater Reclamation Facility in Honokowai where it receives a high level of treatment and disinfection. The Department of Land and Natural Resources, Division of Boating and Ocean Recreation is seeking new federal funding to install an additional pump-out station on the south side of the Lahaina dock.

A booklet, "What Boaters Can Do to Be Environmentally Friendly," was prepared by the West Maui Watershed Management Project and the Lahaina Harbor – Mala Wharf Advisory Committee. This booklet provides information on commonsense approaches to safeguard Maui's marine ecosystems. It is available from the DLNR Harbor Agent in Lahaina or by contacting Department of Health (Environmental Planning Office, 919 Ala Moana Blvd., Honolulu, HI 96814).

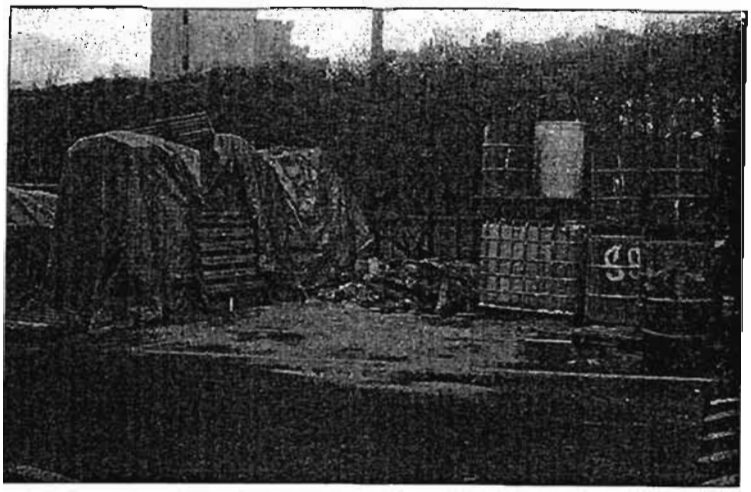


Figure 14. Outdoor storage of building supplies, fertilizers, and cleaning products can result in spills of potentially harmful materials and add to polluted runoff when it rains. Outdoor storage areas should be protected from wind and rain and have a concrete pad to allow clean-up of spills.

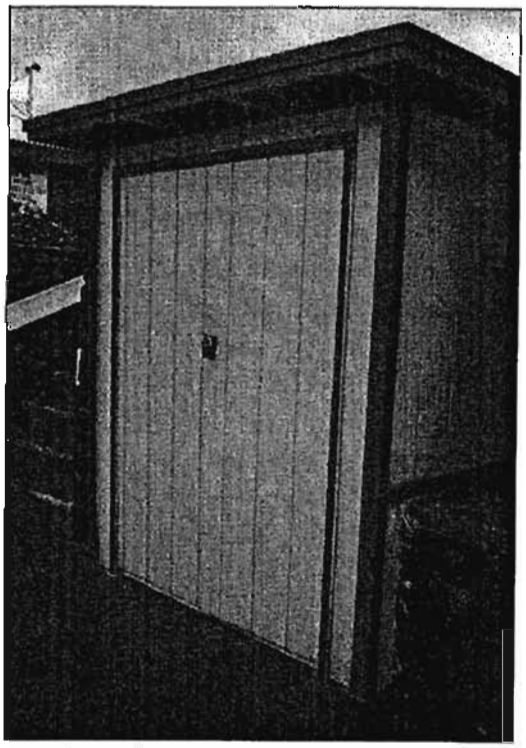


Figure 15. A closet on the north side of the Lahaina dock contains the wastewater pump-out station. Signs should be added to clearly mark the availability of pump-out facilities and provide instructions for obtaining keys and using the pump.

TOP TEN ECO-BOATING PRACTICES

Observe marine toilet rules and discharge only in deep water. Always pump out on shore if you have a holding tank.

Use hard copper, silicone or Teflon bottom paints.

Use phosphate-free biodegradable cleaning products.

Avoid spills and leaks when using paints, solvents, and boat maintenance products.

Properly dispose of all waste on land. Recycle oil, cans, glass, cardboard, plastic, paper, and batteries.

Put fish waste in sealed plastic bags in dumpsters or dispose in deep water.

Keep oil out of bilge water and discharge bilges offshore.

When fueling, don't top-off tanks and do mop up fuel spills. Keep your motors tuned.

Use authorized mooring buoys where available; otherwise anchor in sand or rubble.

Don't feed fish.

Coastal Zone Management Measures:[9]

II. Marina and Boat Operation and Maintenance

A. Solid Waste Management Measure: Properly dispose of solid wastes produced by he operation, cleaning, maintenance, and repair of boats to limit entry of solid wastes into surface waters.

B. Fish Waste Management Measure: Promote sound fish waste management through a combination of fish-cleaning restrictions, public education, and proper disposal of fish waste

C. Liquid Material Management Measure: Provide and maintain appropriate storage, transfer, containment, and disposal facilities for liquid material, such as oil, harmful solvents, antifreeze, and paints, and encourage recycling of these materials.

D. Petroleum Control Management Measure: Reduce the amount of fuel and oil from boat bilges and fuel tank air vents entering marina and surface waters.

E. Boat Cleaning Management Measure: For boats that are in the water, perform cleaning operations to minimize to the extent practicable, the release to surface waters of harmful cleaners, solvents and paint from in-water hull cleaning.

F. Public Education Management Measure: Public education/outreach/ training programs should be instituted for boaters, as well as marina owners and operators, to prevent improper disposal of polluting material.

G. Maintenance of Sewage Facilities Management Measure: Ensure that sewage pump-out facilities are maintained in operational condition and encourage their use.

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[9] The management measure is quoted directly from *Hawaii's Coastal Nonpoint Pollution Control Program Management Plan Volume 1.* See Introduction to Watershed Owners Manual for an explanation of the Coastal Nonpoint Program and management measures.

Tasks to prevent pollution from boats

This section was developed in cooperation with the Lahaina Harbor-Mala Wharf Advisory Committee and with input from the West Maui Watershed Advisory Committee including Skippy Hau, Hannah Bernard, and Ted Grupenhoff.

TASK 1. Educate boaters on what they can do to prevent pollution. (DOH, DLNR, WMWMP)

Distribute brochure: "What Boaters Can Do to be Environmentally Friendly"

Hold workshops to discuss what boaters can do to prevent pollution

Provide a bulletin board for signs and boating information at Mala Wharf

Distribute information to boat crews about environmentally friendly products for boat cleaning and maintenance

TASK 2. Complete the recycling facility for Lahaina Harbor. (Harbor volunteers)

Build the recycling facility

Provide clear signs and instructions for recycling

Notify boat operators about where and how to recycle oil, aluminum, plastic, cardboard and paper at the Harbor, glass at Olowalu.

Add signs and instructions at oil recycling barrels

TASK 3. Promote use of pump-out facilities and observance of marine toilet rules. (Coast Guard, DLNR)

Apply for funding to install additional pump-out facility on south side of Lahaina dock.

Provide wastewater pumpout facilities at Maalaea Harbor as part of the Harbor expansion, and provide mobile pump-out facilities as an interim measure at Maalaea.

Provide incentives for boats to use dockside pumpout facilities. Examples may include:

(1) providing a monetary or other incentive for boats that regularly pump-out,

(2) providing an award or certification that boats can use in promoting their operation as environmentally friendly, or

(3) providing funding or other assistance to boats to help them install hardware needed to use the pump-out station.

Provide signs and instructions for use of existing pump-out facility at Lahaina.

Continue to enlarge and improve restroom facilities at Lahaina Harbor to encourage use of Harbor restrooms rather than marine toilets. County to construct new public restrooms adjacent to Library.

TASK 4. Develop the local capacity to respond to an oil or hazardous material spill in a timely and effective manner. (Coast Guard)

Coast Guard and Area Committee to complete Geographical Response Plan for West Maui

Train more local boaters in oil spill response and develop community response team.

Coast Guard to continue to direct oil spill response efforts and investigate pollution incidents.

Coast Guard to improve enforcement of MARPOL Annex I and V Requirements for oil and waste management.

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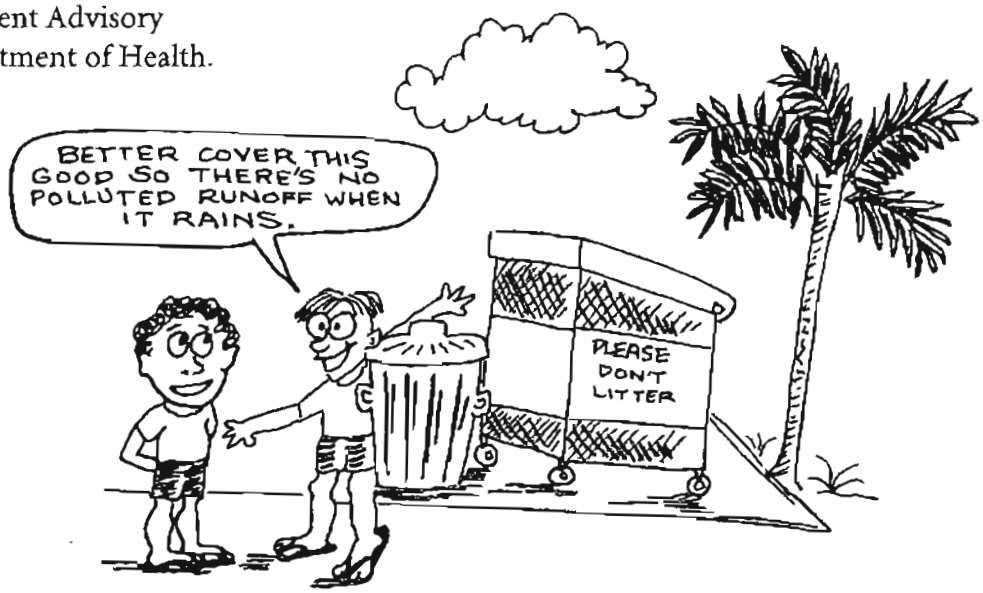

Table 7. Implementation responsibilities for pollution prevention.

MPC Maui Pineapple Company
NRCS Natural Resources Conservation Service
PMC Pioneer Mill Company
UH Ext. Svc. University of Hawaii Agricultural Cooperative Extension Service
WMSWCD West Maui Soil and Water Conservation District
WMWMP West Maui Watershed Management Project

Objective 2A: Prevent pollution from homes & businesses	Maui County	MPC	NRCS	PMC	UH Ext. Svc.	WMSWCD	WMWMP
Task 1. Educate homes and businesses about pollution prevention							✓
Task 2. Develop household hazardous waste disposal program	✓						
Task 3. Train hotels and condos about PP							✓
Task 4. Improve efficiency of fertilizer use for ag		✓	✓	✓		✓	
Task 5. Educate landscape industry					✓		
Task 6. Consider feasibility of leash law	✓						
Task 7. Educate businesses about stormwater PP	✓						

DLNR-DBOR Hawaii Dept. of Land & Natural Resources, Division of Boating and Ocean Recreation
WMWMP West Maui Watershed Management Project

Objective 2B: Prevent pollution from boats	Boat operators	DLNR-DBOR	Dept. of Health	Maui County	US Coast Guard	WMWMP
Task 1. Educate boaters on pollution prevention	✓	✓	✓		✓	✓
Task 2. Complete the recycling facility	✓	✓				
Task 3. Promote use of pump-out facilities & observance of marine toilet rules	✓	✓	✓	✓	✓	
Task 4. Develop local capacity for spill response	✓	✓			✓	

CHAPTER 3

PROMOTE IMPROVED WATER MANAGEMENT PRACTICES

Watershed Objective 3: Promote improved water management practices

Identification of the problem

In seasons when rainfall is below normal, the demand for water exceeds the available supply. By far the largest water use in West Maui is sugar cane irrigation at Pioneer Mill. Other water users include Maui Pineapple Company (agricultural irrigation), County of Maui (drinking water), Kapalua Water Company (drinking water, golf course irrigation), and Kaanapali Water Corporation (drinking water), and AMFAC (golf course irrigation). Water shortages affect Pioneer Mill most strongly; in dry years they are not able to supply enough water to their fields to maximize sugar cane production. Pioneer Mill Company, Kaanapali Estate Coffee Inc., and Maui Pineapple Company will suffer reduced yields as a result of the summer 1996 drought.

The water supply for West Maui is a combination of surface sources diverted from major streams through a series of ditch systems and ground water wells. According to the Maui County Water Use and Development Plan, diversions of surface streams supply approximately 42 mgd of water to West Maui. Approximately 22 mgd are pumped from groundwater wells in West Maui. Most of the groundwater pumped is brackish water used for sugar cane and golf course irrigation; the remainder is used by County of Maui, Kapalua Water Company, and Kaanapali Water Corporation for public domestic uses, which includes both drinking and irrigation water.

All of the public water supply wells in West Maui are located in the Honolua, Honokowai, and Launiupoko aquifers. The estimated sustainable yield of these aquifers for potable quality water is approximately 8 mgd each (M&E Pacific, 1992). When all 6 Lahaina sector aquifers from Honokohau to Ukumehame are considered, the estimated total sustainable yield for potable water from groundwater sources is 40 mgd. The conversion of agriculture to drip irrigation and a continuous reduction in acres of sugar cane production, may adversely affect the future rate of aquifer recharge, resulting in reduced sustainable yield of the Honokowai to Ukumehame aquifers.

Under the existing water use scenario, there is a shortage of water supply in dry years. The demand for water is increasing. The Honokohau Valley Association is requesting an increase in the amount of water flowing through Honokohau Stream in order to expand taro production and restore the stream's habitat, functions, and native fisheries. Villages of Leiali'i, when fully developed, is expected to need about 3 mgd. Drinking water will be supplied by wells in the Honokowai aquifer and reclaimed water will be used for landscape and golf course irrigation. The resident population of West Maui is projected to increase from 14,600 (1990 census) to 21,000-22,600 by 2010. During the same period, the visitor population is expected to increase from 20,000 to 32,000-37,700.

PIONEER MILL'S SUGAR CANE IS THE BIGGEST WATER USER IN WEST MAUI. IN DRY YEARS, THEY ARE THE HARDEST HIT BY WATER SHORTAGES.

The vulnerability of West Maui's drinking water wells to chemical contamination underscores the need to better protect the quality of our water supplies from contamination in the future. The contaminant 1,2 dibromo-3chloropropane (DBCP) has been detected in 6 wells in the Napili/Mahinahina area. This chemical was legally applied to kill nematodes in pineapple fields before it was banned in 1985. The contaminant 1,2,3 trichloropropane (TCP) has been detected in 3 wells in the Kaanapali area. The exceedance of drinking water standards for DBCP and TCP in ground water wells (after treatment and dilution, tap water supplied to homes in West Maui complies with drinking water standards) confirms that West Maui's ground water wells are vulnerable to chemical contamination. Groundwater wells south of Honokowai Stream where pineapple has not been grown are not contaminated, but may be vulnerable to chemical contamination under different future land use conditions.

Also, chloride levels in groundwater pumped in West Maui sometimes exceed the 250 parts per million drinking water standard, indicating that too much water is pumped from some wells. The chloride situation should improve when both the Mahinahina and Lahaina Water Filtration Plants are in full operation. These surface water treatment facilities will lessen the need to pump large quantities of groundwater to supply drinking water.

The Maui County Water Use and Development Plan (M&E Pacific, 1992) states that Maui should look to alternative water sources, wastewater reclamation and water conservation to help meet future water demands. The easily developed sources of water are already in production. Developing new sources to expand the supply of potable and irrigation water will be more difficult and more expensive. Future water sources will also be further from the point of use, and require more expensive infrastructure to deliver the water.

In addition to water supply, wastewater treatment is an important aspect of water management. Most of the water consumed for non-agricultural uses in West Maui enters the sewage collection system and is treated at the Lahaina Wastewater Reclamation Facility (LWRF) in Honokowai. The collection system serves Lahaina from Puamana to the Ritz Carlton. At LWRF an average flow of about 5 mgd of wastewater is treated to advanced secondary level, disinfected, and disposed in four injection wells 180-230 feet deep. Until recently, this wastewater collection and treatment system had serious problems including raw sewage spills from the collection system, infiltration of seawater, and deteriorating infrastructure. The County has since rehabilitated the wastewater collection system and upgraded the treatment system. As a result, problems have been minimized.

Although the vast majority of West Maui is served by the Lahaina wastewater collection and treatment system, about 256 lots at Wahikuli, the Civic Center complex, and about 45 other properties use individual septic systems and cesspools. Cesspools provide little treatment and breakdown of wastes. Dissolved organics, nutrients, bacteria and viruses from cesspools can move with the flow of groundwater and seep into the ocean near the shoreline. Elevated concentrations of nutrients from cesspools have been reported in coastal waters where the nuisance alga *Hypnea* is abundant (Bourke, 1996; Dollar and Andrews, 1997). The four major areas where *Hypnea* occurs (Chart House, Wahikuli, Mahinahina, and Kahana to Honokeana) do have coastal cesspools nearby (Figures 16a & 16b).

What's being done to improve water management in West Maui?

Water conservation expands the number of service connections that can be served by the existing water supply, delays the need for new wells or additional stream diversions, and lowers pumping and treatment costs (Vickers and Markus, 1992). Another benefit of conserving water for domestic uses is the reduced volume of wastewater requiring treatment, which may postpone expensive expansions to sewage treatment plants. Many communities in the U.S. have reduced water consumption by 22-25% through voluntary conservation measures (Shaw, et.al. 1992).

The use of low-flow fixtures is mandated for all plumbing sales and installations after 1992 by Maui County Plumbing Code Chapter 16.2. The Maui County Board of Water Supply (BWS) and Wastewater Reclamation Division (WRD) have both initiated water conservation efforts. In conjunction with Maui Electric Company they offered an incentive program to retrofit showerheads with water saving models and provide free toilet flappers to reduce water use for old toilets. Both departments have active public education programs that include school programs and exhibits at special events. BWS has initiated public service announcements on radio to promote water conservation. The new water rate structure for BWS provides an incentive for conservation by charging higher rates to large volume users within all user categories, except agriculture. BWS also has implemented an audit and leak detection program for Maui's water delivery system.

Both Pioneer Mill and Maui Pineapple Company use drip irrigation in all fields, except those sugar fields irrigated with wastewater from the sugar mill. Information on water conservation, the low-flow requirements of the County Plumbing Code, and water-efficient landscaping is provided to developers and businesses during the permitting process by BWS.

Wastewater reclamation is a viable alternative water source in the Lahaina and Kihei areas, especially for agricultural and landscape irrigation. The Lahaina Wastewater Reclamation Facility was recently expanded to a treatment capacity of 9 mgd. Improved treatment made possible by the expansion and addition of sand filtration and ultraviolet disinfection produces 3 mgd of "R1"[10] effluent, the cleanest wastewater effluent in the State.

Maui County adopted a new ordinance "Use of Reclaimed Water" Chapter 20.30 of the Maui County Code in 1996. Kaanapali Golf Course now uses approximately 1.3 mgd of reclaimed water for irrigation. A pilot project testing reclaimed water for pineapple irrigation began in July 1997 and Pioneer Mill is evaluating the possibility of irrigating sugar cane seed stock with reclaimed water. Maui County's WRD has an active outreach program in public and private schools for promoting water conservation and reclaimed water use.

FREE WATER-SAVERS

Did you know that the largest water user in your home is the toilet? The Maui County Wastewater Reclamation Division and Board of Water Supply are sponsoring free retrofit programs for older toilets and showers. Call Steve Parabicoli at 243-7426 for toilet flappers that take two minutes to install and can reduce your water use by 20 to 25%. Call Ellen Kraftsow at 243-7199 for free water-saving shower heads.

[10] R1 means reclaimed water that has been treated to produce significant reduction in viral and bacterial pathogens and is considered by Hawaii Dept. of Health to be safe for all landscape and most agricultural irrigation.

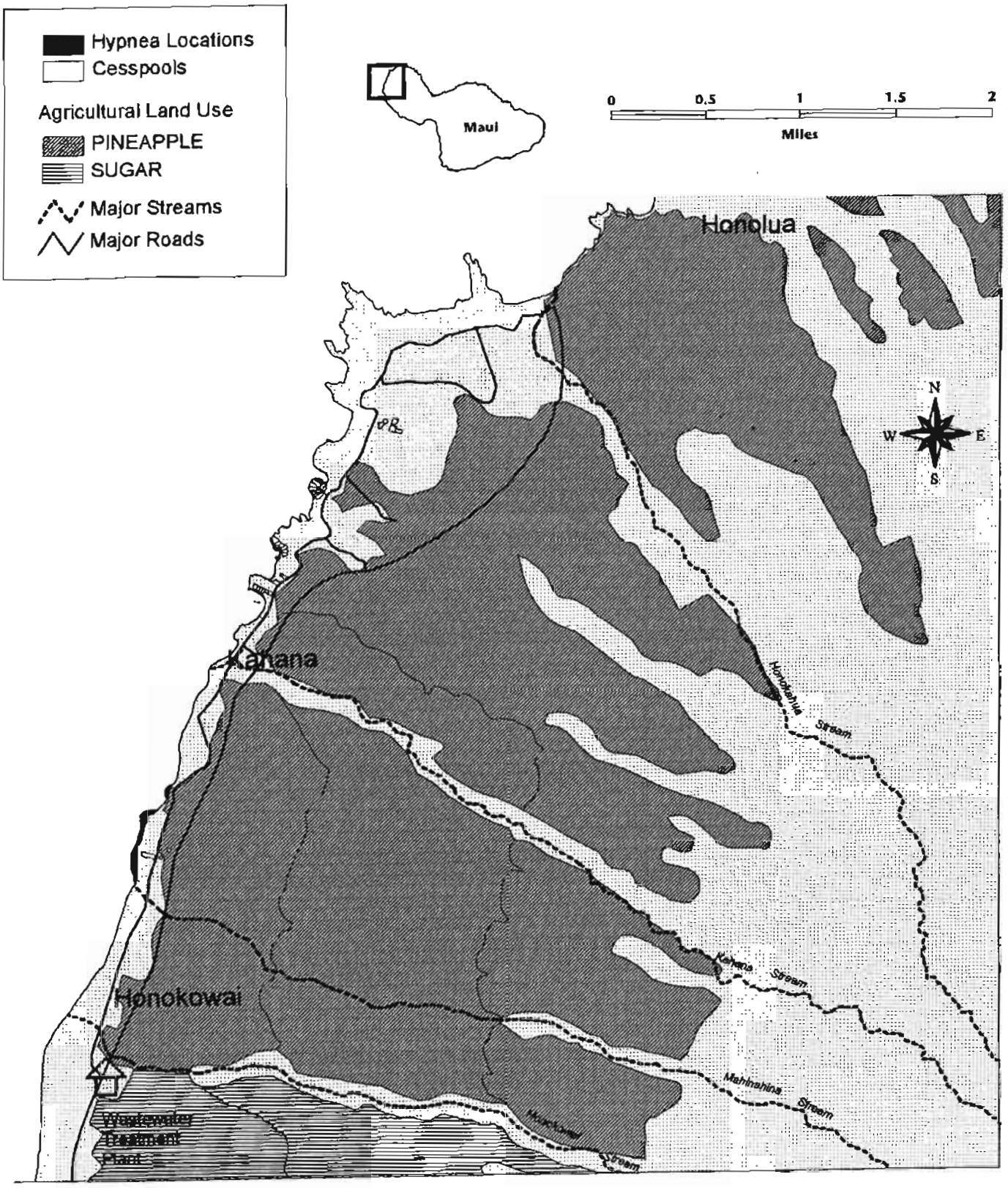

Figure 16a. Map of shoreline from Kapalua to Honokowai showing locations of *Hypnea*, cesspools, Lahaina's wastewater treatment plant and agricultural land use. Note waterfront cesspools in Mahinahina, Kanaha and Napili areas.

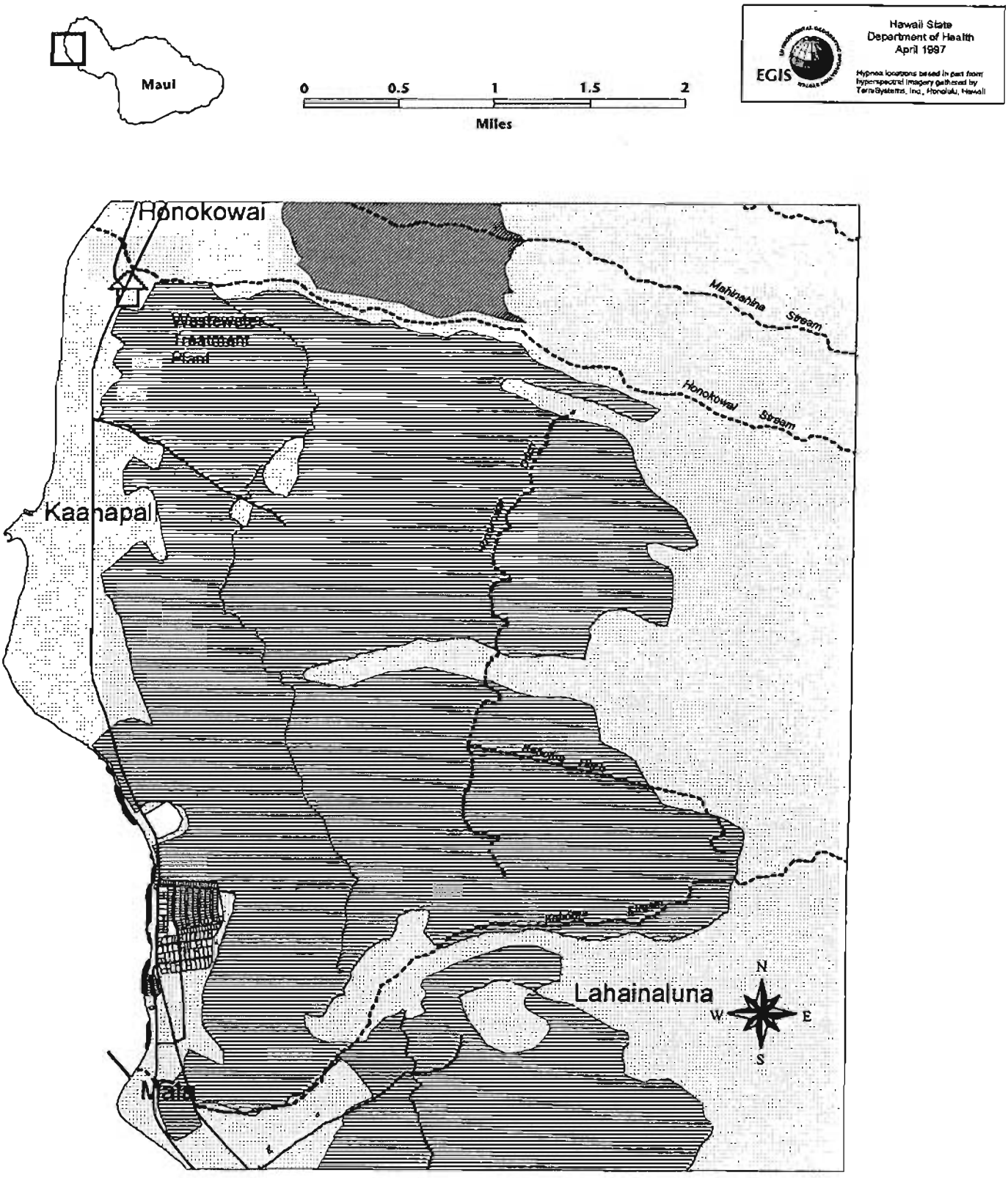

Figure 16b. Map of shoreline from Honokowai to Lahaina showing locations of *Hypnea*, cesspools, Lahaina's wastewater treatment plant and agricultural land use. Note large areas using cesspools at Civic Center Complex, Wahikuli, and Chart House area of Front Street.

Figure 17. Signs posted at Kaanapali Golf Course and roadside areas notify people that recycled water is used for irrigation. The use of recycled water helps to expand our water supply and reduce the amount of wastewater going to injection wells at the Lahaina Wastewater Reclamation Facility.

Protecting stream and groundwater sources of drinking water is the right thing to do. It preserves our resources for the future and is less costly than cleaning up contaminated water supplies.

The 1996 Amendments to the Safe Drinking Water Act require states to develop source water protection programs and provide funds for assessment and protection efforts. The Maui BWS has taken the first steps toward source water protection in West Maui. The Water Use and Development Plan is being revised by BWS to take a more integrated water resource management approach (see AWWA, 1994), including planning that incorporates reclamation, source water protection, and conservation. BWS completed delineation of wellhead protection areas for all of West Maui's drinking water wells and ranked the vulnerability of these supplies to chemical contaminants such as pesticides (Hagemann and Fukunaga, 1997).

We are fortunate that the forests and surface water supplies are well protected in West Maui (see Chapter 5). Puu Kukui Preserve has been actively protected and managed for weeds and ungulates (pigs and goats) since 1987 by Maui Land and Pineapple Company (ML&PC), The Nature Conservancy (TNC), and Hawaii Dept. of Land and Natural Resources (DLNR). The forest of Kapunakea Preserve (1264 acres) has been actively protected and managed since 1990 by Pioneer Mill, and The Nature Conservancy.

Discussions are in progress among all large West Maui watershed land owners (BWS, Bishop Estate, C. Brewer Company, DLNR, ML&PC, Pioneer Mill Co., TNC) regarding expansion of forest protection areas and development of an integrated forest protection program for the West Maui Mountains. The West Maui Watershed Management Project has allocated seed money to develop a cooperative integrated management project for the West Maui forest ecosystem. The BWS budget for 1997-98 also includes funds to help support a partnership for protecting the forested watershed in West Maui.

Tasks to promote improved water management practices

TASK 1. Expand water conservation efforts.

Survey hotels and condos about their use of water conservation measures and target needed improvements through BWS's educational outreach program or with a Pollution Prevention training and certification program funded by West Maui Watershed Project. (BWS, WMWMP)

Revise water bills to show records of usage over last year for each residence/business (in process for BWS). (BWS, Kapalua Land Company Water Dept., Kaanapali Water Corporation)

Create additional incentive programs (like MECO-BWS shower head program) to encourage retrofit of plumbing for residences, condos, hotels and businesses.

(BWS, Kapalua Land Company Water Dept., Kaanapali Water Corporation)

Expand public education campaign to promote water conservation, including curricula for schools. (BWS, MC-Public Works and Waste Management)

Encourage private water companies to develop conservation-based rate schedules and promote conservation. (Kapalua Land Company Water Dept., Kaanapali Water Corporation)

Encourage BWS and private water companies to implement voluntary water system audit programs to identify and repair leaks and improve conservation for homes and businesses. (BWS, Kapalua Land Company Water Dept., Kaanapali Water Corporation)

Identify and reduce leaks in the Honolua/Honokohau ditch system. (Maui Pineapple Company, Pioneer Mill Company)

Require individual water meters for all new developments, condos, apartments, shopping centers, restaurants and markets so that water use can be tracked for individual units. (BWS)

Model water conservation at County parks by using low-flow shower heads, diverting shower runoff for landscape irrigation, and using non-invasive climate-adapted ground covers and plants. Use reclaimed water for irrigation at parks located adjacent to reclaimed water lines. (Maui County, BWS)

Finalize BWS ordinance pertaining to water-efficient landscaping.

TASK 2. Expand use of reclaimed water in West Maui, especially for agricultural and landscape irrigation makai of well-head contribution areas.

Identify condos and hotels in the Kaanapali area that are interested in using reclaimed water and develop the infrastructure to provide service to them. (WMWMP, MC-Public Works and Waste Management)

Provide additional incentives to encourage agricultural use of reclaimed water, especially for sugar cane and irrigation of resort landscaping. (MC-Public Works and Waste Management)

Increase storage capacity for reclaimed water in West Maui by constructing a storage reservoir at lower elevation than present reservoir, to reduce pumping costs and increase availability and reliability of reclaimed water supply (MC-Public Works and Waste Management).

Revise Department of Health's Guidelines for the Treatment and Use of Reclaimed Water to reflect current implementation practices that streamline permitting for reuse and to clarify monitoring requirements. (DOH)

Expand public education efforts to promote use of reclaimed water. (DOH, MC)

TASK 3. Evaluate the contribution of coastal cesspools to nuisance algal blooms and recommend appropriate management strategy.

Complete studies to determine (1) if nutrients from coastal cesspools have significant impact on *Hypnea*, (2) whether eliminating coastal cesspools will reduce *Hypnea* biomass, and (3) whether bacterial counts indicate a possible health problem for swimmers. (DOH)

Develop a brochure and public outreach program to educate homeowners about maintenance of cesspools and septic systems. For coastal cesspools, recommend that homeowners install water-saving plumbing fixtures and appliances, and discourage use of garbage disposals and detergents with phosphates. (DOH)

Adopt proposed revisions to Hawaii Administrative Rules Chapter 11-62 to clarify state requirements and to include all Maui as a Critical Wastewater Disposal Area where cesspools are prohibited. (DOH)

If studies verify link between algal problems and coastal cesspools, develop a strategy for (1) eliminating coastal cesspools and shallow injection wells and (2) design and permitting of new wastewater disposal systems in coastal areas. (DOH, MC-Public Works and Waste Management).

Evaluate the feasibility of drilling deep injection wells (>1,000 feet) to replace existing wastewater injection wells, or in lieu of new shallow wells (DOH, MC-Public Works and Waste Management)

TASK 4. Develop a source water protection program for groundwater and surface water.

Expand forest protection efforts to include an integrated plan for entire West Maui Mountain system. (BWS, DLNR, The Nature Conservancy, land owners)

Update Maui Water Use and Development Plan for West Maui using an integrated water resources management approach, taking into account water conservation and reclamation. (BWS)

Board of Water Supply, with Advisory Committees chosen from agencies, technical experts, and concerned citizens, will develop a source water protection program for West Maui. (DOH)

The Board of Water Supply and committees will assess upgradient pollutant sources for surface and groundwater sources of drinking water and develop pollution prevention measures to protect source water.

TASK 5. Incorporate information on hydrogeological cycles, watershed structure and function, and water resource management into school curricula. (Soil & Water Conservation Districts, Maui's schools, Maui County)

Adapt existing curricula to be more reflective of Hawaii's watersheds.

Build on existing educational programs and fund raising of Soil and Water Conservation Districts, involve Olinda/Kula and Hana Districts.

Train teachers to use curricula on watersheds and water resource management.

Promote the use of KidScience Water Watch videos, produced by Hawaii Dept. of Education for PBS, in Maui's classrooms for grades 3-5.

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CHAPTER 4

PROMOTE URBAN STORMWATER MANAGEMENT PRACTICES THAT ARE PROTECTIVE OF OCEAN WATER QUALITY

Watershed Objective 4: Promote urban stormwater management practices that are protective of ocean water quality

Identification of the problem

When it rains, part of the water that falls to the ground is taken up by the soil and plants, some evaporates, and the rest runs off the surface of the soil and into storm drains, streams, or directly into the ocean. Water that infiltrates into the ground helps to replenish our aquifers which are underground reservoirs of fresh water. Storm water runoff carries sediments, trash, motor oils, landscape chemicals, pet feces and other pollutants to our streams and coastal ocean.

Plants enhance the ability of the soil to absorb and hold water, and they help prevent erosion. For example, Stevenson (1997) reported that mature sugar cane fields, with their deep root systems and tall dense plants, can absorb a great deal of rainfall from intense rain storms without generating significant runoff.

On the other hand, buildings, roads, parking lots and other impervious surfaces eliminate the ground's ability to absorb water. One often overlooked result of development is the potential for increased runoff, flooding, downstream erosion, and reduced coastal water quality. In places where development has increased the area of impervious (paved) surfaces, there will be more water moving makai at higher velocities.

Another potential impact of development on storm water flows is the loss of flood storage capacity. Development in low lying flood plain and flood storage areas usually involves fill to raise the elevation above flood level. Filling low lying land will generate more runoff from new impervious surfaces, and the water that historically pooled at the site will be transported makai.

We all know that storm water runoff carries sediments to the ocean. The coastal waters are typically muddy for days after a big rain storm. One unusual summer storm in 1993 left West Maui's coastal waters turbid and red for a period of 4 months. The persistence of muddy water varies greatly from place to place along the shore. In areas with strong currents, even the sediments carried by major streams may clear in a day.

Figure 18. This attractively landscaped water holding pond was designed into a new development at Kai Ala Place. A series of landscaped depressions helps to retain flood waters and partially compensate for the fill and impervious surfaces that will increase runoff from the fully developed site.

In sheltered bays and coves, or when the surf is particularly low, the muddy water persists for several days or weeks. Volunteers are monitoring turbidity at locations along the West Maui shore to characterize the persistence of muddy water at different sites there. Sites that consistently have high turbidity include Hanakao'o (canoe beach), Papakea, S-Turn, Kahana, and Kaopala (Fig. 1).

Research by Stevenson (1997) and Soicher and Peterson (1996) showed that most of the suspended sediment in West Maui's streams results from erosion on agricultural lands. Some sites in urban areas are also susceptible to erosion, particularly construction sites and roadsides. Construction sites can be a significant source of sediments in runoff entering coastal waters particularly where the new development is close to the ocean.

Most people don't realize that storm water runoff from our streets and communities is a problem. Studies of the invisible pollutants in urban runoff prove otherwise. Polluted runoff from residential and business streets is a major source of nutrients, hydrocarbons, pesticides, and bacteria entering our beaches and coastal waters. Stevenson's (1997) study of runoff in West Maui found that urban runoff had higher concentrations of phosphorus (a nutrient that can stimulate algal growth) than runoff from pineapple, sugar cane or forest land (see Chapters 1 and 2). Fertilizer applied to landscaping is believed to be the source of the phosphorus in urban runoff.

A field survey of 82 sites in the storm drainage system of West Maui was conducted to identify illicit discharges of pollutants and other problems (Woodward-Clyde, Consultants 1996). The major pollutants identified in West Maui's storm drains were sediment, litter, and oil (Table 8).

Table 8. Categorization and frequency of pollutant observations at 82 sites within the storm drain system of West Maui in 1996.

Pollutant source category	Frequency of occurrence (% of sites)
Sediment	21.9
Litter	19.5
Oil	12.2
Landscape Debris	8.5
Storage & Maintenance Debris	7.3
Swimming Pool Filter Water	6.1
Cleaning Fluids & Debris	4.9
Concrete/Grout	3.7
Paint	3.7
Other Illicit Discharge	4.9

From Woodward-Clyde, Consultants, 1996.

It makes sense during the planning stages for new projects to incorporate best management practices to minimize the amount of runoff and remove pollutants. Pollutant removal should focus on sediment, litter, oil, and fertilizers. Runoff problems will become worse as Maui's population grows because buildings, roads, parking lots, and other paved areas reduce the area of soil surface available to absorb water. Although some assert that drainage improvements are too costly, the hidden costs of flood damage and coastal pollution are also a financial burden to the community. Some developments are experiencing difficult public review periods or even lawsuits over the adequacy of drainage facilities to protect downstream property and water quality. Good drainage design and planning now can reduce the cost of damage to property and the visitor industry in the future.

SEDIMENT, LITTER, OIL AND FERTILIZERS ARE THE POLLUTANTS OF CONCERN IN WEST MAUI'S STORM WATER RUNOFF.

What's being done to control urban stormwater runoff?

The "Stormwater and Drainage Management Plan for West Maui" (Woodward-Clyde, Consultants 1996) was developed by the West Maui Watershed Project to recommend cost-effective, reliable, and sustainable control measures to reduce pollutants in urban runoff, particularly nutrients and sediments (W-C: Section 7). This document describes the current storm water management programs and practices that are applicable to Maui County (W-C: Section 5). It includes an assessment of the storm drain system for West Maui and of illicit discharges (W-C: Section 5, Appendix A), including descriptions of illicit discharges and maintenance and repairs that are needed. Many of the "tasks" identified in this chapter are based on recommendations by Woodward-Clyde, Consultants.

One of the major recommendations in the "Stormwater and Drainage Management Plan..." is to increase the numbers and storage capacity of sediment retention basins within the major streams. This action will add to peak flood attenuation and improve sediment removal. However, nearly all of the urban development in West Maui is located makai of the existing sediment retention basins. Consequently the sediments and other pollutants contained in runoff from urban development are not retained by the sediment retention basins. The storm water collection systems that exist in the developed lands of West Maui allow litter and pollutants in runoff to pass directly to the streams and ocean.

A storm drain stenciling program has marked many of the storm drains on Maui with signs that say "Don't Dump...Drains to Ocean." This program was initiated in 1994 by the West Maui Watershed Project and the NOAA Hawaiian Islands Humpback Whale National Marine Sanctuary. Since then, Community Work Day volunteers and several youth groups have expanded the stenciling effort.

Figure 19. West Maui Watershed Coordinator, Dr. Wendy Wiltse, promotes a community effort to stencil storm drains with "DON'T DUMP . . . DRAINS TO OCEAN" at the Maui County Fair.

Maui County Department of Public Works and Waste Management will be establishing a telephone "hot line" to take complaints about illegal discharges to storm drains, runoff from construction sites, and other related activities. In the meantime, an "Information Request Form" (Figure 20) can be submitted to Department of Public Works at 200 S. High Street, Wailuku, HI 96793 (phone: 243-7845; fax: 243-7955) to report complaints.

Maui County's grading ordinance is being revised to better address environmental concerns, including but not limited to water quality. The County received a Nonpoint Source Control Grant awarded by the Department of Health, under section 319 (h) of the Clean Water Act for revising the grading ordinance and providing training in erosion control methods for inspectors and the development community. The revisions are expected to be adopted in 1997. Control of erosion and runoff from construction sites is discussed in greater depth in Chapter 1.

Maui County adopted "Rules for the Design of Storm Drainage Facilities" in 1995. This is an important step because the drainage requirements for new developments are

clearly spelled out in the rule. The Rules protect adjacent and downstream properties from adverse effects of runoff. They require retention of runoff generated onsite by new development, if the existing drainage system is inadequate to handle added flows. Alternatively, the drainage system can be upgraded to handle the increased flows from new developments. The Drainage Rules do not require best management practices to remove pollutants from runoff.

GOOD DRAINAGE DESIGN AND PLANNING NOW CAN REDUCE THE COST OF DAMAGE TO PROPERTY AND THE VISITOR INDUSTRY IN THE FUTURE.

There are federal requirements that apply to the management and control of stormwater runoff. Section 402 of the Clean Water Act requires NPDES permits for municipal storm drainage systems serving communities with greater than 100,000 population and for stormwater discharges associated with industrial activity. Maui County's population now exceeds 100,000 and a NPDES permit will be required for Maui County after the next census in the year 2000.

Until Maui County has an NPDES storm water permit, urban runoff on Maui is subject to requirements of the Coastal Zone Management Act (CZMA), Section 6217 (g). The 1990 amendments to the CZMA recognized that nonpoint pollution is a key factor in the continuing degradation of many of the nation's coastal waters. These amendments require States to develop Coastal Nonpoint Pollution Control Programs to manage storm water discharges that are not covered by NPDES permits. Hawaii has incorporated the CZMA Section 6217 (g) management measures into the Coastal Nonpoint Pollution Control Program Management Plan Volume 1, completed in June 1996. The full implementation of these management measures is required by 2004. The specific management measures that apply to urban runoff are quoted below.

INFORMATION REQUEST FORM

DEPARTMENT OF PUBLIC WORKS

Please
- ☐ READ
- ☐ HANDLE
- ☐ APPROVE

and
- ☐ FORWARD
- ☐ RETURN
- ☐ KEEP OR DISCARD
- ☐ REVIEW WITH ME

TO: _____

DIV: _____

FROM: _____

REQUESTOR: _____ RECEIVED BY: _____

ADDRESS: _____ DATE: _____

_____ TIME: _____

TELEPHONE: _____

REQUEST: _____

COMMENTS: _____

ACTION TAKEN: _____

DATE CHECKED: _____

CHECKED BY: _____

WAS REQUESTOR INFORMED? _____

(PLEASE RETURN ONE COPY TO THE OFFICE OF P. W. DIRECTOR WHEN RESOLVED)

Figure 20.

SIMPLE WAYS TO REDUCE STORMWATER POLLUTION

Recycle used motor oil. Used oil fuels the Sugar Cane Train.

Label storm drains: DO NOT DUMP, DRAINS TO OCEAN. Educate others.

Expand litter control and street sweeping efforts.

Use spill-proof garbage cans.

Cover refuse dumpsters.

Reduce erosion at construction sites. Keep all soil and runoff onsite.

Use less fertilizer and use slow-release types.

Minimize use of high phosphate fertilizer like 10-30-10.

Route parking lot runoff onto grass or vegetation rather than directly to storm drains.

Coastal Zone Management Measures: [11]

II. Urban Runoff

A. New Development Management Measure.

1. By design or performance:

(a) After construction has been completed and the site is permanently stabilized, reduce the average annual total suspended solid (TSS) loadings by 80%. For the purposes of this measure, an 80% TSS reduction is to be determined on an average annual basis, or

(b) Reduce the postdevelopment loadings of TSS so that the average annual TSS loadings are no greater than predevelopment loadings, and

2. To the extent practicable, maintain postdevelopment peak runoff rate and average volume at levels that are similar to predevelopment levels.

Sound watershed management requires that both structural and nonstructural measures be employed to mitigate the adverse impacts of stormwater. Nonstructural Management Measures II.B and II.C can be effectively used in conjunction with Management Measure II.A to reduce both the short-and long-term costs of meeting the treatment goals of this management measure.

II.B. Develop a watershed protection program to:

(1) Avoid conversion, to the extent practicable, of areas that are particularly susceptible to erosion and sediment loss;

(2) Preserve areas that provide important water quality benefits and/or are necessary to maintain riparian and aquatic biota; and

(3) Site development, including roads, highways, and bridges, to protect to the extent practicable the natural integrity of waterbodies and natural drainage systems.

IIC. Site Development Management Measure

Plan, design, and develop sites to:

(1) Protect areas that provide important water quality benefits and/or are particularly susceptible to erosion and sediment loss;

[11] The management measures are quoted directly from *Hawaii's Coastal Nonpoint Pollution Control Program Management Plan Volume 1.* See Introduction to Watershed Owners Manual for an explanation of the Coastal Nonpoint Program and management measures.

(2) Limit increases of impervious areas, except where necessary;

(3) Limit land disturbance activities such as clearing and grading, and cut and fill to reduce erosion and sediment loss;

(4) Limit disturbance of natural drainage features and vegetation.

IV. Existing Development

A. Existing Development Management Measure

Develop and implement watershed management programs to reduce runoff pollutant concentrations and volumes from existing development:

(1) Identify priority local and/or regional watershed pollutant reduction opportunities, e.g., improvements to existing urban runoff control structures;

(2) Contain a schedule for implementing appropriate controls;

(3) Limit destruction of natural conveyance systems; and

(4) Where appropriate, preserve, enhance, or establish buffers along surface waterbodies and their tributaries.

VII. Roads, Highways, and Bridges

VII.E. Management Measure for Operation and Maintenance

Incorporate pollution prevention procedures into the operation and maintenance of roads, highways, and bridges to reduce pollutant loadings to surface waters.

VII.F. Management Measure for Road, Highway, and Bridge Runoff Systems

Develop and implement runoff management systems for existing roads, highways, and bridges to reduce runoff pollutant concentrations and volumes entering surface waters.

(1) Identify priority and watershed pollutant reduction opportunities (e.g. improvements to existing urban runoff control structures); and

(2) Establish schedules for implementing appropriate controls.

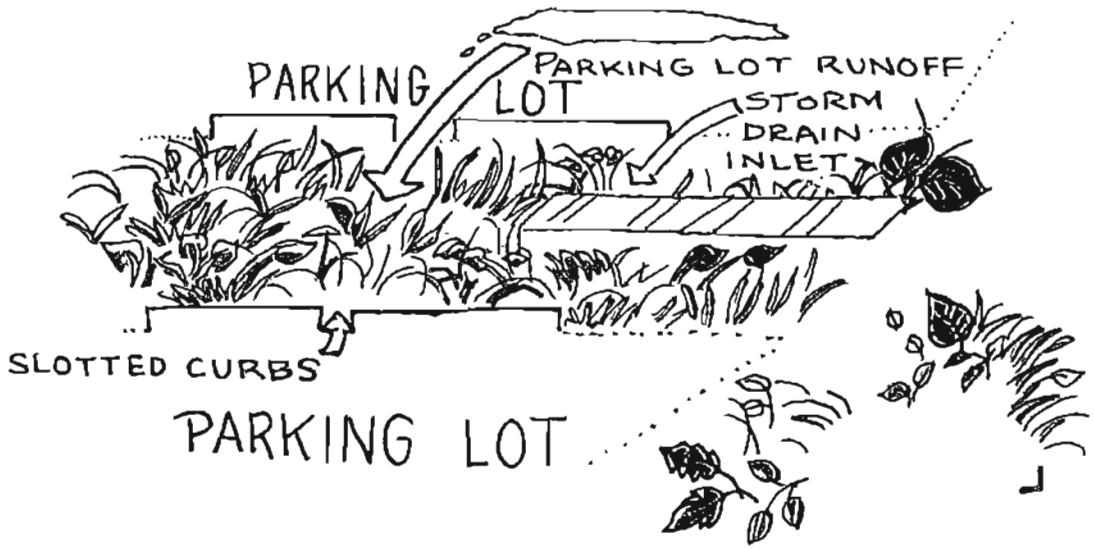

Figure 21. In order to remove some pollutants from parking lot runoff, water should be directed through a vegetated area. Here the storm drain inlet is surrounded by vegetation which helps to remove sediments, nutrients, oils and other pollutants from runoff.

Tasks to promote urban stormwater management practices that are protective of ocean water quality

These recommendations are based in large part on the "Stormwater and Drainage Plan for West Maui" (Woodward-Clyde, 1996). Howard Hanzawa, George Kaya, Daren Suzuki, and Skippy Hau participated in the review and discussion of these tasks.

TASK 1. Incorporate structural and nonstructural stormwater management practices that are protective of ocean water quality into plans for new development. (Maui County Depts of Public Works and Planning)

Establish a "stakeholder" workgroup to revise the drainage standards for Maui County to (a) require that drainage system designs will not adversely affect downstream and coastal water quality, and (b) incorporate the following elements into the design of permanent drainage systems:

- Maintain pre-development hydrological conditions of velocity, and volume. Require best management practices to compensate for increased runoff volumes and velocities generated by increased areas of impervious surface. Limit post-construction peak discharge rate and volume for all development so that water discharged offsite for a 2-year, 24-hour storm event (or other justifiable size of storm event) does not exceed pre-development flows.
- Reduce erosion and polluted runoff. Remove suspended solids and associated pollutants entrained in runoff from developed sites, at a minimum for the first flush of runoff (i.e. first half inch of runoff).
- Protect areas that provide important water quality benefits by assessing and establishing adequate setback distances near wetlands, inland waterbodies, wellhead contribution zones, the shoreline, and riparian areas; preserve flood plains and flood storage areas.
- Retain the hydrological structure and function of natural drainage systems by protecting the natural integrity and function of waterbodies, natural drainage features, flood plains, flood storage, and vegetation, to the extent practicable. Require compensation to maintain water quality functions impaired by modifications to natural drainage systems (e.g. promote infiltration, reduced erosion, uptake of nutrients and pollutants by plants, filtering and settlement of sediment particles).
- Encourage the siting of drainage outlets in areas with strong currents and good mixing. Site outlets on land that projects into the ocean, away from beaches and protected embayments.
- Consider establishing limitations on percentage cover of impervious surfaces for new developments in areas where runoff is directed to a semienclosed water body (e.g. a harbor or embayment), "high turbidity area" (see Chapter 2), stream with limited capacity, or other sensitive area.

Revise County policies for zoning, subdivisions, and standard details to promote the following:

- Minimizing the percent of impervious areas by allowing:

  1. Cluster zoning that allows buildings to be "clustered" more densely on the portion of the site most suitable for development, in exchange for preserving contiguous open space to protect natural drainage features and sensitive habitats.

  2. Narrow streets and finger road layouts for residential development. Evaluate "skinny street" policies from Oregon.

- Partial removal of sediments, oils and other pollutants from runoff by designing:

  1. Parking lots that drain to vegetated areas rather than directly into subsurface storm drains.

  2. Depressed grassy medians within roadways to collect runoff.

  3. Storm drain inlets surrounded by vegetation (recommended radius = 5 ft.)

- Preservation and maintenance of drainage features by property owners.

Develop guidance for SMA permit applicants and reviewers regarding Drainage and Erosion Control Plans. Guidance should include:

- Analysis of cumulative impacts of existing and planned development on (a) downstream peak flow rate and average volume of runoff; and (b) flood storage, flooding, and coastal water quality. (Project reviews are currently conducted project-by-project and do not routinely consider average volume of runoff, flood storage capacity, or coastal water quality on a regional scale.)
- Site plan showing how offsite runoff from mauka areas will be directed, during and after construction.
- Demonstration that onsite retention is adequate to retain new runoff generated onsite from a 2-year 24-hour storm event (or other justifiable size of storm event).
- Listing of design features that encourage infiltration of stormwater runoff, including: retention of stormwater on individual lots, on-site retention in common areas, infiltration trenches and basins, maximizing landscaped areas, minimizing directly connected impervious surfaces, directing roof runoff to vegetated areas or dry wells, and draining parking lots to depressed vegetated areas. Drainage plan to specify which features will be incorporated.
- Listing of design features that help to remove pollutants from runoff, including: detention and desilting basins, grass filter strips, sand filters, oil filters, and grassed swales. Drainage plan to specify which features will be used on-site.
- Instructions for erosion control site plans consistent with revisions to Maui County Grading Ordinance.

TASK 2. Develop and implement management practices to reduce pollutant concentrations in runoff and runoff volumes from existing development. Emphasize control of sediment, litter, oil and fertilizers. (Maui County, Cooperative Extension Service)

Develop an educational program for Maui's residents and businesses with emphasis on preventing polluted runoff. "Island Stewardship: Guide to Preventing Water Pollution for Maui's Homes and Businesses" contains recommendations and best management practices. These should be incorporated into a video, public service announcements, and school curricula.

Institutionalize, possibly in conjunction with Community Work Day, the labeling of storm drain inlets with permanent signs that say "Don't Dump...Drains to Ocean" or similar message. Ensure that all storm drain inlets are labeled and that labels are reapplied as needed.

Expand public education about how and where to recycle used motor oil.

Improve enforcement of requirements for disposing of swimming pool water. Preferred method is to discharge to a dry well or directly onto a lawn or vegetation. Discharge to the sanitary sewer without a permit is illegal.

Clean all sediment retention basins at least once each year.

Expand litter control efforts, including more frequent emptying of public trash barrels and spill-proof trash cans.

Educate the landscaping industry about avoiding overuse of fertilizers.

Develop a household hazardous waste disposal program to encourage the proper disposal of household chemicals.

Establish a "hotline" phone number to take complaints about illegal dumping in storm drains, flooding, erosion, and other runoff problems. Develop procedures for responding to complaints and ensure that complaints receive follow-up.

Encourage the use of drip irrigation in lieu of spray irrigation for landscape watering to reduce runoff and overspray.

When planning drainage improvement for existing developments, incorporate best management practices (e.g. grassed swales, filter strips, sand filters, settling ponds, curb cuts to direct runoff into vegetated areas) to reduce pollutants in first flush (0.5 in.) of runoff.

Establish an "Adopt-a-Stream" program to keep streams free of debris and litter.

Encourage sweeping up of leaves and twigs to prevent them from entering storm-drains.

TASK 3. Incorporate pollution prevention procedures into the operation and maintenance of roads, highways, and bridges to reduce pollutant loadings to surface waters. (State Dept. of Transportation, Maui County)

Develop simple concise guidance describing water quality pollution prevention related to road maintenance activities and distribute to all State and County Highway Department staff. Management practices should include the following:

- Increase the frequency of street sweeping to at least once each quarter (national runoff studies recommend a frequency of twice a week).
- Clean all storm drain catch basins at least once each year and improve maintenance of the storm drain system. The "Stormwater and Drainage Management Plan for West Maui" (Woodward-Clyde, Consultants, 1996. Appendix A) contains a list of needed storm drain and catch basin repairs and maintenance.
- Do not leave stockpiled soil on the makai side of roads. Stockpiled soil should be left only on the mauka side of the road, covered, and only on a temporary basis.
- All roadsides and roadcuts should be stabilized with vegetation to reduce erosion. Drought-tolerant, slow growing plants will reduce maintenance costs.
- Soils disturbed during maintenance activities should be stabilized and revegetated or otherwise protected from erosion soon after the work is completed.
- All road maintenance materials, such as asphalt or concrete, should be controlled and not allowed to enter drainage ways, nor be vulnerable to being transported by runoff.
- Road resurfacing or paving should not be performed within 24 hours of a predicted significant (greater than 0.5 in.) rain event.

TASK 4. Evaluate options for improving the design of flood protection and drainage channels to promote infiltration, remove sediments, encourage migration of native fish and shrimp, and reduce ponding at the makai end. (Maui County, WMWMP)

TASK 5. Develop a stormwater management program for Maui County that meets the intent of Section 402 of the Clean Water Act or Section 6217 of the Coastal Zone Management Act. (DOH, Maui County)

Figure 22. Formation of a sand bar or barrier at the stream outlet is one of the drawbacks with the design commonly used for stream channels. These channels work well to protect adjacent properties from flooding, but the standing water behind the sand bars often elicits complaints about noxious odors.

References

Soicher, Alan and Frank Peterson. 1996. Assessing terrestrial nutrient and sediment discharge to the coastal waters of West Maui, Hawaii. Prepared for NOAA Coastal Ocean Office.

Stevenson, Marty. 1997. Nutrient and Suspended Solid Loadings in Surface Runoff from Four Land Use Categories in the Honokowai Stream Drainage Basin, Lahaina District.

Woodward-Clyde, Consultants. 1996. Stormwater and Drainage Management Plan for West Maui. Prepared for Hawaii Department of Health.

WHAT MAUI CAN DO TO REDUCE URBAN RUNOFF PROBLEMS

Manage runoff for drainage basins, rather than individual lots. Take into account the cumulative impacts of existing and planned development throughout the drainage system.

Design drainage systems to protect downstream property and coastal water quality by:

1. Designing new developments to maintain predevelopment runoff conditions (peak flow and average volume) for average storms.
2. Using simple Best Management Practices to remove sediments and other urban pollutants from the "first flush" of storm runoff.
3. Preserving the structure and function of natural drainage systems.

Educate residents, landscapers, businesses, and school children about what they can do to prevent water pollution.

CHAPTER 5

PROTECT NATIVE FOREST ECOSYSTEMS

Watershed Objective 5: Protect native forest ecosystems

Why protect native forest ecosystems?

Native ecosystems are unique assemblages of flora and fauna interacting in dynamic balance. Many of the plants and animals are endemic to Hawaii. Native ecosystems have intrinsic value as a whole and for the unique elements they contain. These native ecosystems provide essential habitat for the majority of the 273 endangered species in Hawaii. In fact, over 50% of the native plants in Hawaii are listed as endangered, threatened, candidate, or species of concern by U.S. Fish and Wildlife Service.

This chapter discusses efforts to protect native Hawaiian forest ecosystems in West Maui. The West Maui Watershed Management Project recognizes that although forests are the largest native ecosystem comprising 50% of the watershed area, they are not the only native ecosystems that need protection in West Maui. Streams, riparian areas, wetlands, and coral reefs are also important to watershed function and management and as habitat for plants and animals.

The structure and function of the West Maui Watershed is significantly altered from its natural state. Water is diverted from streams and transported via ditch systems to irrigate agricultural fields in dry areas, altering the hydrology and habitat of streams and the patterns of groundwater recharge. Streams that flowed continuously throughout the year now only flow intermittently during heavy rainfall. The coastal flood plains and wetlands that trapped sediments and supported unique water fowl and wildlife are now filled and developed with resorts and homes. Streams have been channelized to prevent flooding of valuable coastal properties built in the flood plain. Sediment retention basins were constructed to trap sediments before they enter the ocean, a function of former wetlands. Native fish ('o'opu) and shrimp ('opae) that formerly migrated up streams from the ocean cannot do so because of dry stream beds, high temperatures in concrete channels, and large dams.

The focus of our watershed management efforts in West Maui has been primarily on reducing sediment and nutrient inputs to the ocean. Although we did not direct much effort toward protection of stream and reef habitats, we expect that streams and reefs will benefit from the implementation of management practices to protect coastal water quality. We recommend that watershed management efforts be expanded to include protection of native stream, wetland, and coral reef habitats in West Maui, if future efforts allow.

Forested watersheds serve crucial functions on which both quantity and quality of ground and stream water depend (Figure 23). These functions include: (1) collection of water; (2) storage of water; (3) discharge of water; (4) attenuation of the erosive impacts of sudden, heavy rainfall events; (5) cycling of nutrients; and (6) biological breakdown and flushing of contaminants, and moderation of these processes.

These functions have direct value to the agricultural and urban water users at lower elevations. They also play a role in coastal

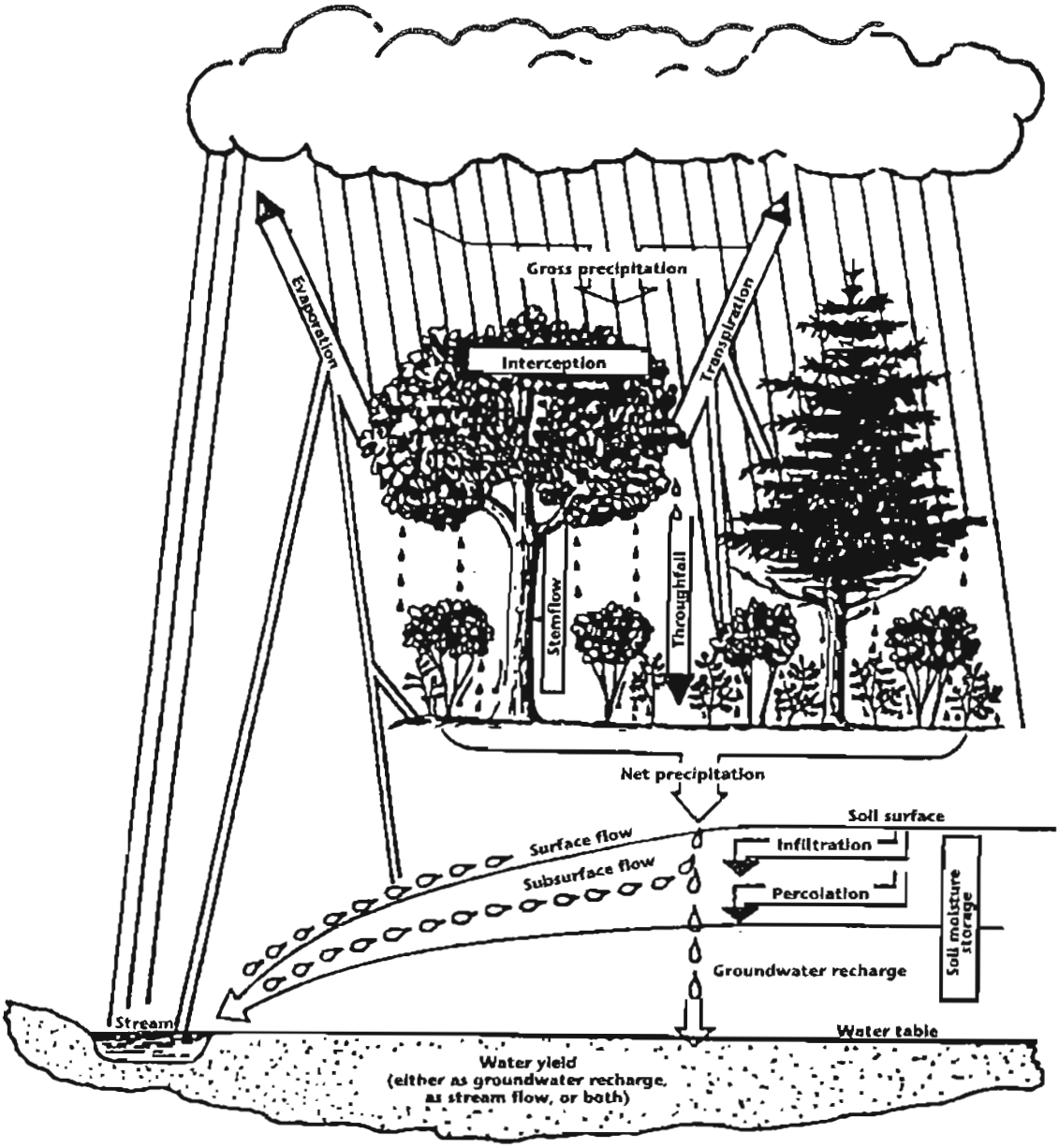

Figure 23. Illustration of the role forests play in the hydrological cycle and watershed protection. (Source: Cassells, Hamilton & Saplaco)

water quality because the majority of stream runoff and groundwater that reaches the ocean originates as rainfall in the forests. Runoff from forests contributes about 25 to 35% of the total sediment load in Honokowai stream, as compared to 65 to 75% from agricultural land (Soicher and Peterson, 1996).

In native Hawaiian forests, the thick carpet of moss and other bryophytes on the forest floor serves to collect, or hold water, and to reduce erosion and run-off in storms. This same mossy carpet releases water slowly into both the ground and streams. The native Hawaiian cloud forest is characterized by multiple tiers and layers of canopy. This dense forest cover is protective against erosion, and increases "fog drip," by providing opportunity for condensation. This fog drip represents a crucial fraction of groundwater recharge.

However, the degradation of native forests by invasion of alien species typically involves loss of the vital bryophyte layer.

Invading species can also form monotypic stands, effectively eliminating the multi-tiered canopy in large areas of the watershed. This can severely reduce water recharge.

Disturbance of the native forest by foraging pigs and goats is destructive to the vegetation and leaves the soil exposed and vulnerable to erosion. Alien plants quickly become established in such disturbed areas, eliminating the moss and multi-tiered canopy structure of the native forest. Many of these invasive alien plants have shallow root systems which in turn may lead to increased susceptibility to erosion and the potential for landslides.

The West Maui Mountains provide habitat for 42 known endangered species. The condition of the forested watershed area in the West Maui Mountains ranges from very good to seriously disturbed, according to Bob Hobdy (Dept. of Land and Natural Resources). The west slope from Honokohau to Ukumehame is in good condition, especially the protected Puu Kukui and Kapunakea Preserves where the number of pigs is extremely low. East of Honokohau, the Eke Section of the West Maui Natural Area Reserve is also protected at higher elevations. The lower Kahakuloa lands have more pigs and evidence of disturbance. The Wailuku Agribusiness lands from Waikapu to Waihee have healthy forest in the upper reaches, but have fairly serious problems with pigs, goats, and weeds in lower elevations.

What's being done to protect native forests?

Several forested areas in West Maui are currently managed for watershed protection and conservation of native species, as listed in Table 9. The locations of these preserves are shown in Figure 24. Management efforts include removal of weeds, fencing to exclude pigs, reduction of pig populations inside fences, and managed hunting.

Table 9. Forest management areas in West Maui and management partners.

Management area	Partners
Pu'u Kukui Preserve	Maui Land & Pineapple Company, The Nature Conservancy, Dept. of Land and Natural Resources
Kapunakea Preserve	Pioneer Mill Company, Ltd., The Nature Conservancy, Dept. of Land and Natural Resources
West Maui Natural Area Reserve	Dept. of Land and Natural Resources
West Maui Forest Reserve	Dept. of Land and Natural Resources

The County Board of Water Supply (BWS) recently purchased 5,000 more acres of forested watershed in Waihee Valley, half in fee and half in management easement. BWS is in the process of having preliminary assessment and management recommendations for this area prepared by staff of Department of Land and Natural Resources (DLNR) and the National Tropical Botanical Garden. In addition, The Board of Water Supply, DLNR, The Nature Conservancy of Hawaii, and private landowners are in the process of forming a partnership to develop a coordinated management program for the West Maui Mountains. This partnership will be modeled after the East Maui Watershed Partnership and will be the first management effort in Hawaii to include all of the landowners for an entire mountain forest system.

To help prevent further spread of alien species, efforts are underway to educate developers, landscapers and the public about invasive and native plants (Figure 25). BWS sends out educational materials and recommendations for climate-adapted native and non-invasive non-native species with reviews of all new developments. The Hawaiian Ecosystems at Risk project, co-sponsored by the University of Hawaii and the Biological Resources Division of the United

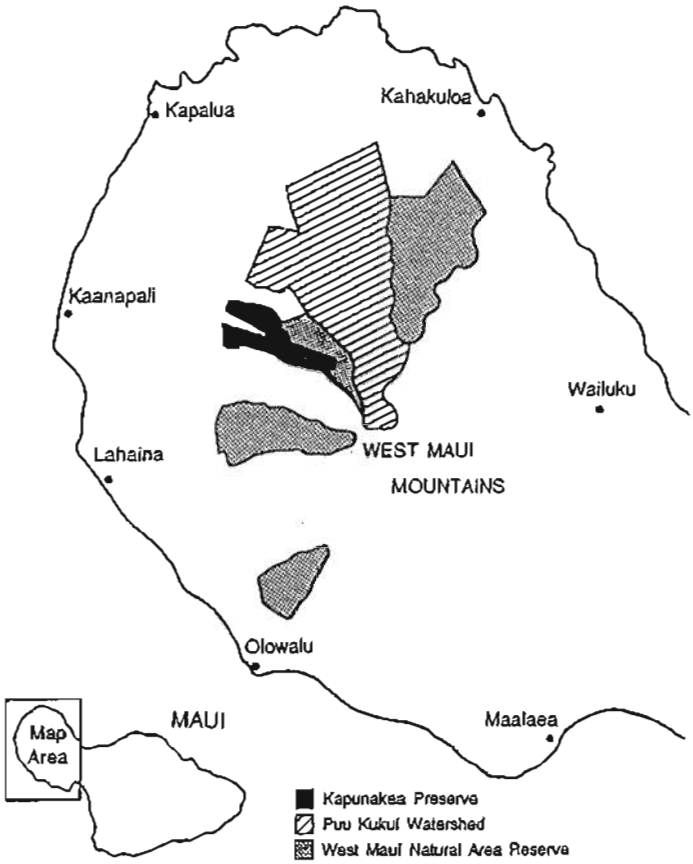

Figure 24. Map showing locations of protected forest reserves in West Maui Mountains.

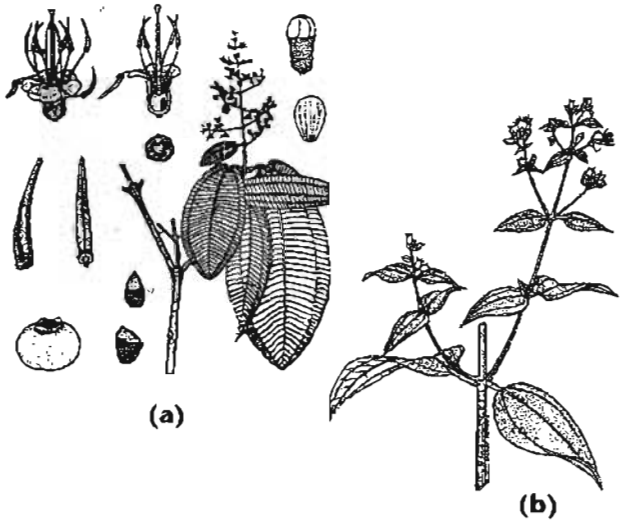

Figure 25. Two invasive plants that should be avoided for landscaping in Maui are (a) *Miconia calvescens* and (b) *Tibouchina herbacea*. Drawings from *Manual of the Flowering Plants of Hawaii, Volume 1* by Wagner, Herbst, and Sohmer.

States Geological Survey, provides on-line lists of invasive plants to avoid planting, data and articles on invasive species, and links to related information (www.hear.org).

The Hawaii State legislature passed Act 73 in 1992 and 1993 which requires all new capitol improvement projects to include some native and/or Polynesian introduced plants. The *Maui County Planting Plan* (for a copy call 243-7325) has a listing of 125 native and Polynesian trees, shrubs, and groundcovers recommended for use in landscaping. This book lists the space required, the amount of water the plants need, their flower color, wind and salt tolerance, and many other characteristics.

If you have questions about growing native plants in your area and wonder where you can get them, you can call Anna Palomino at 572-4835, Richard Nakagawa at 877-4024, and Ray Keenan at 875-9557.

Tasks to protect native forests

TASK 1. Finalize formation of a West Maui Watershed Partnership and develop a coordinated forest management agreement. (BWS, DLNR, TNC, PM, ML&PC, Bishop Estate, C. Brewer Co.)

Finalize assessment/review and recommendations for management of BWS watershed holdings.

Establish appropriate fencing programs where needed and maintain existing fencing programs. (DLNR, BWS, ML&PC, PM)

Maintain managed hunting. (DLNR, ML&PC)

Maintain existing programs for invasive species removal and expand efforts where needed. (DLNR, BWS, ML&PC, TNC)

Identify potentially invasive species that have not yet become so widespread as to be major control problems. Early detection and removal of problem species leads to cheaper and more successful control. (DLNR, TNC, ML&PC)

Monitor progress of alien species removal and native species recovery, and adjust management efforts as appropriate. (DLNR, TNC, ML&PC)

TASK 2. Expand educational efforts for the public on how they can prevent the spread of non-desirable species and help protect the forests. (DLNR, TNC, BWS, National Tropical Botanical Garden, Biological Resources Division of USGS)

Expand public education and demonstration sites about (1) the use of climate-adapted native plants for landscaping and (2) avoidance of invasive species.

Encourage communities to establish design guidelines that include recommended and discouraged species of plants, based on water and fertilizer requirements and potential for invasive spreading.

TASK 3. Expand watershed management efforts to develop recommendations for protecting other native ecosystems, including streams, riparian areas, wetlands, and coral reefs and for preserving and restoring their important watershed functions.

Include in these recommendations the promotion of native Hawaiian riparian systems, taro agriculture and other Hawaiian practices.

WHAT YOU CAN DO TO PROTECT NATIVE FORESTS

Learn about native plants suited to your area, and use them in landscaping and gardens.

Learn about invasive species, and AVOID using them in landscaping.

Report sightings of *Miconia* or other invasive species to the USGS Biological Resources Division at 572-9306-5-5938, to DLNR-DOFAW at 984-8100, or to the Board of Water Supply at 243-7199.

Volunteer for service trips with The Nature Conservancy, DLNR, and Maui Land & Pineapple Company for opportunities to experience and learn about native forests while helping to remove invasive plant species or replant native species.

Practice water conservation (see Chapter 3 and Island Stewardship Guide).

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Wagner, Warren, D.R. Herbst, and S. H. Sohmer. Manual of the Flowering Plants of Hawaii, Volume 1. University of Hawaii Press.

Thanks to Ellen Kraftsow, Maui County Board of Water Supply and Bob Hobdy, Hawaii Department of Land and Natural Resources for contributing to Chapter 5.

CHAPTER 6

ENCOURAGE ALGAE CLEAN-UP AND BENEFICIAL USE

Watershed Objective 6: Encourage algae clean-up and beneficial use

What is an algal bloom?

Algae, or limu, are marine plants, natural components of our marine habitats. A bloom is an excessive growth or proliferation of one or a few species of algae. Blooms become a problem when algae accumulates on the shore where it rots and smells, forms thick floating rafts nearshore, or accumulates on the ocean bottom where it smothers corals and other marine life.

Algal blooms are a worldwide phenomenon in ponds, lakes, streams, and coastal oceans. These blooms may involve macroalgae, like the red and green nuisance algae on Maui, or microscopic plants called phytoplankton. Macroalgal blooms are not generally associated with human health problems, other than the noxious odors of hydrogen sulfide produced when algae decay. Phytoplankton blooms, on the other hand, can consist of toxic red tides that result in fish kills or shellfish poisoning in humans. We're fortunate that these toxic phytoplankton blooms are not common in Hawaiian waters.

Algal blooms are naturally occurring events, known since biblical times. Experts agree that the impact and number of nuisance blooms are on the rise worldwide.

LIKE CROPS, ALGAE NEED NITROGEN & PHOSPHORUS IN ORDER TO GROW.

Although the causes are not completely understood, there is compelling evidence that nutrient enrichment (nitrogen, phosphorus, iron) of coastal waters is at least partly to blame for such blooms (Vitousek, et.al. 1997). It is quite likely that nutrient enrichment has already contributed to long-term declines in the world's coastal fisheries and accelerated losses of plant and animal diversity. The challenge for scientists is to find evidence that allows natural causes and cycles in algal abundance to be distinguished from events that are related to human-caused pollution.

What are the factors that may trigger algal blooms? Algae are plants, and like crops, flowers, and grass they need essential nutrients (fertilizer) to grow. In coastal waters, the most important nutrients are nitrogen and phosphorus. Nitrogen is limiting (i.e. adding nitrogen triggers growth) to algal production in most coastal areas in the temperate zone, but in tropical waters, phosphorus or nitrogen may be the limiting nutrient. Human-influenced sources of these nutrients include sewage, fertilizers, and soils originating in the coastal watershed. These nutrients may enter the ocean through streams, runoff, groundwater seeps, discharge pipes, or by atmospheric deposition. Nutrients from the sea floor sediments or deep ocean water may also come to the surface on occasion and stimulate algal blooms.

Species introductions could result in blooms of algae. Alien species may proliferate greatly in a new environment where natural controls by disease, competitors and

herbivores are lacking. There are numerous examples in Hawaii where introduced plants and animals have become extremely abundant, especially in disturbed habitats. An alien species may decline in abundance over time as it comes into balance with the environment.

While nutrients are necessary for algal blooms to occur, other factors can also regulate algal blooms. These include temperature, currents and waves, residence time of the water, light intensity, habitat availability, and grazing by herbivores. When a combination of these factors is optimal for the growth of a particular type of algae, a bloom may occur.

Algal blooms on Maui

The blooms that occur on Maui involve three types of macroalgae or limu: *Cladophora*, *Hypnea*, and *Ulva* (limu palahalaha). Generally one type predominates in a bloom condition, although other algae may be present in smaller quantities (Fig. 26). Each type of alga has a specialized habitat and set of conditions under which it may bloom.

✦ *Cladophora*

Cladophora is a green thread-like alga. It occurs world-wide as a fast growing alga typical of nutrient rich waters. It may exhibit bloom and bust growth cycles with fluctuating abundance. *Cladophora* usually grows in deeper waters outside the reefs of West Maui, from 30-100+ feet deep. It starts off growing attached to the calcareous alga Halimeda but may break off and drift in the water column with the currents. *Cladophora* is episodic, sometimes growing at a location, then disappearing (Bourke 1996).

A bloom of *Cladophora* was first reported in June 1989. That summer, it was reported at depths ranging from 20 to 140 feet. Bloom conditions persisted through September with moderate to heavy quantities reported from Oneloa Beach (Ironwoods) to Mala Wharf. One report noted *Cladophora* as far north as Honolua Bay in 45 feet of water.

While *Cladophora* was again reported in March 1990 between Honokowai Point and Mahinahina Stream, a nuisance bloom never developed in that year.

In February 1991 a new bloom of *Cladophora* was reported at depths of 40 to 100 feet near Kaanapali. By late April, the bloom was reported from Hawea Point to Lahaina Roadsteads at depths of 20-60 feet. This bloom persisted through the summer and was reported on national TV news.

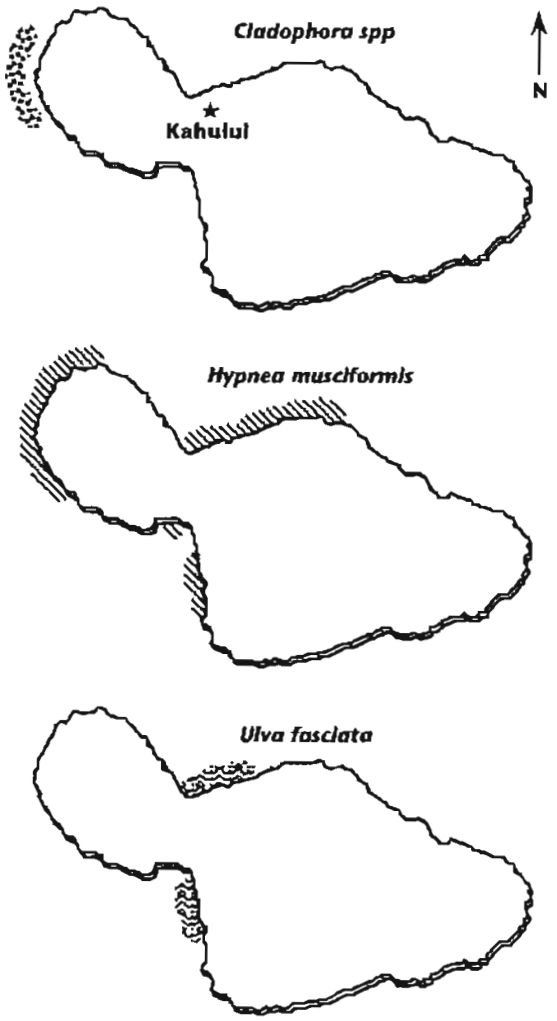

Figure 26. Distribution of nuisance accumulations of three types of algae (*Cladophora*, *Hypnea*, *Ulva*) on Maui. Figure from Hodges (1996).

During these blooms, the *Cladophora* drifted inshore where it settled in dense masses on the ocean floor, apparently smothering corals and other reef organisms. The *Cladophora* also accumulated on beaches and created very unpleasant conditions for marine recreation.

Between 1991 and 1996, *Cladophora* has been reported growing off West Maui but has not developed into a nuisance bloom. Bourke (1996) describes the fluctuations in seasonal distribution and abundance of *Cladophora* at four sites off West Maui from 1993-1996.

✦ *Hypnea*

Hypnea musciformis is classified as a "red" alga, although it ranges in color from a golden brown to purple. It typically grows attached to rocks in shallow water, less than 10 feet deep. It is native to the Atlantic Ocean, from Massachusetts south to tropical South American waters, from West Africa to the Bay of Biscaye and is also commonly found in the Indian Ocean, from East Africa to India.

In Hawaii, *Hypnea musciformis* is an exotic that was introduced at Kaneohe Bay on Oahu in January, 1974 (Russell and Balazs, 1994). Others suggest *Hypnea* was introduced to Pearl Harbor after World War II through the discharge of bilge water by ships. At Kaneohe Bay, *Hypnea* was planted on reefs in an attempt to farm it for production of carrageenan. Its rapid dispersal in Hawaii is probably due to a high growth rate, abundant production of spores, ability to grow from fragments, and to attach as an epiphyte (a plant living on another plant) on other algae, or directly to rocks. *Hypnea* spread from Oahu to Maui against the prevailing currents, suggesting that it was transported on boat hulls. The first publicly reported occurrence of *Hypnea* on Maui was in 1985 along the south shore.

The first complaints of rotting accumulations of *Hypnea* were from Kuau Bay in 1986. In West Maui, the first recorded complaints were from Hoyoshi Nikko Condominiums in Mahinahina in February 1987. That year, *Hypnea* was also reported to be a problem in Paia, Kihei, Maalaea, Honokowai, and Launiupoko. Volunteers have reported accumulations of *Hypnea* on beaches in West Maui, Maalaea, Kihei, Sprecklesville, Paia, and Kuau during 1995-6 (Hodges 1996).

Hypnea plants fragment easily and the free-floating algal fragments continue to grow as they drift in the nearshore waters (Figure 27). Accumulations of *Hypnea* on the beaches appear to be strongly influenced by currents and surf conditions. This growth-breakage-growth aspect of *Hypnea*'s biology may result in a substantial accumulation of beach wrack from a relatively small biomass of growing plants.

Figure 27. Volunteers attempt to remove drifting *Hypnea* at S-turns in Kahana. The dark areas in the photo are drifting rafts of *Hypnea* formed by plant fragments that have broken loose from shallow rocks along the shoreline.

✦ *Ulva*

Ulva is a green alga known as sea lettuce or limu palahalaha. It is a fast growing algae which typically dominates in locations where there is freshwater input from streams or groundwater seeps. This is the dominant species of nuisance algae in Kahului Harbor

and in Kihei in the vicinity of Menehune Shores and Kalepolepo (Hodges 1996). *Ulva* is widely distributed around Maui in shallow waters and often occurs mixed in with piles of *Hypnea* on the shoreline. In West Maui *Ulva* occurs in isolated patches, but *Hypnea* is always the predominant type of algae in shoreline piles.

Research on the algal blooms on Maui

Federal funds were appropriated to National Oceanic and Atmospheric Administration (NOAA) and the U.S. Environmental Protection Agency (EPA) to identify both the causes of algal blooms on Maui and likely solutions. State funds were allocated to the Department of Health (DOH) for study of the distribution and biology of algal blooms on Maui. A workshop was held at the National Marine Fisheries Service (NMFS) Honolulu Laboratory in February 1993 to identify research needed to understand the causes of *Cladophora* and *Hypnea* blooms in West Maui. The technical reports on the findings of the research efforts are listed in Table 10.

The research projects funded by NOAA, EPA, and DOH are organized into four topics: (1) algal distribution and biology, (2) loadings of nutrients from different land-based sources, (3) nutrients in coastal waters and their contribution to macroalgal blooms, and (4) physical processes that may influence algal blooms. A summary of findings and recommendations is presented in Appendix F.

These research reports were critically reviewed by nationally recognized experts in coastal ecology. The reports and the peer reviews are available at the Lahaina Public Library, Maui District Health Office (54 Wells Street, Wailuku), and at the Department of Health, Environmental Planning Office (919 Ala Moana Blvd., Honolulu, HI 96814).

Algal distribution and biology

Although it is extremely abundant at some locations and is not native to Hawaii, *Hypnea musciformis* apparently has little effect on the reef community. Hodgson (1994) compared the percent cover of macroalgae, density of sea urchins, and percent cover of corals and zooanthids, along a transect at Maalaea in 1978 and 1993. The only change over that time period was an increase in the percent cover of macroalgae, due to the addition of *Hypnea* to the area. The abundance of urchins and corals was very similar in the two years of the study.

Dollar and Andrews (1997) used a newly developed application, multispectral imaging, to map areas along the West Maui shoreline where attached *Hypnea* was abundant (Figs. 16a & 16b, see Chapter 3). The regions of high *Hypnea* abundance (from north to south) are Honokeana Cove, Mahinahina Stream to S-turn Park, Wahikuli, and the shoreline between the Chart House Restaurant and Lahaina Cannery Mall. While the abundance of *Hypnea* may vary with the seasons and surf conditions, *Hypnea* is consistently present in these areas.

Hodges (1996) volunteer monitoring project reports the distribution of *Hypnea* and *Ulva* washed up on beaches from West Maui to Kihei and Spreckelsville to Kuau. Results from this project are discussed in the Introduction (pages 14-15). The beach sampling by volunteers is continuing in 1997 with the intent of tracking changes in the distribution of nuisance algal accumulations over time.

THE NUISANCE ALGA HYPNEA IS AN INTRODUCED SPECIES. LIKE MANY ALIEN SPECIES, IT "GROWS LIKE A WEED" AND IS DIFFICULT TO CONTROL.

Table 10. List of state and federally funded research projects investigating the algal blooms in West Maui.

Project title	Investigator(s)	Funded by:	Completion date
Algal distribution and biology			
Maui algae bloom studies: Distribution and abundance	Robert Bourke, Oceanit Laboratories, Inc.	DOH, NOAA	Oct-96
Baseline survey of seaweeds in West Maui	Lynn Hodgson UH, West Oahu	DOH	Jul-94
Monitoring of blooms of *Hypnea* and *Ulva* on Maui	Marc Hodges	NOAA	Dec-96
Predicting growth and biomass accumulation of *Hypnea*	Sean Anderson & Peggy Fong, UCLA	NOAA	Dec-96
Loadings of nutrients from different land-based sources			
Terrestrial nutrient and sediment sources and transport	Alan Soicher & Frank Peterson, UH	NOAA	Sep-96
Assessment of nutrient and sediment contributions from 4 land use classifications	Marty Stevenson Kinnetic Laboratories, Inc.	NOAA	Mar-97
Preliminary assessment of anthropogenic nutrient sources	Tetra Tech, Inc.	EPA	Jun-93
Nutrient concentrations in coastal waters			
Assessment of suspended solids and particulate nutrient loading to surface runoff and the coastal ocean	Eric De Carlo & Steve Dollar, UH	EPA	Mar-97
Algal blooms off West Maui: Assessing causal linkages between land and coastal ocean	Steve Dollar & Christine Andrews UH	NOAA	Mar-97
Effluent fate study	Tetra Tech, Inc.	EPA	Feb-94
Physical processes that may influence blooms			
Maui algal bloom study: Role of ocean physics	Charles Sun NOAA	NOAA	Oct-96
Observations of currents through Pailolo channels: Implications for nutrient transport	Pierre Flament & Claude Lumpkin, UH	NOAA	Dec-96

Causes of *Hypnea* blooms on Maui

The majority of research focused on *Hypnea*, the red alga that grows in a narrow band of shallow water along the shore. A combination of several factors — elevated nutrient levels in the nearshore water, suitable substratum, moderate levels of water motion, lack of natural grazers (because *Hypnea* is introduced to Hawaii), and high growth rates — provide a set of conditions that result in abundant *Hypnea* populations (Dollar and Andrews 1997).

The studies by Dollar and Andrews (1997) and Soicher and Peterson (1996) compared sources of nutrient inputs to the coastal waters and investigated whether these nutrients control the abundance of *Hypnea* in West Maui. Their findings are summarized here.

There are elevated concentrations of dissolved nitrogen and phosphorus in the narrow band of nearshore water where *Hypnea* thrives, as compared to ocean water further from shore. The major source of the nutrients is from groundwater seeps along the shoreline. About 87% of the nitrate in groundwater results from leaching of fertilizers applied to large-scale agriculture (Soicher and Peterson, 1996). Because phosphorus readily adsorbs to soil particles, there is little phosphorus in groundwater and little subsidy of phosphorus from agricultural activity.

The other source of nitrogen and phosphorus, that may be significant in localized areas, is leachate from cesspools and septic systems of residences that are not connected to the municipal sewer. Since cesspools provide no sewage treatment capacity, most of the nutrients and bacteria from the residential wastewater can pass through cracks in the lava into the coastal waters near the shoreline. Groundwater containing cesspool leachate is likely to be enriched in phosphorus, relative to groundwater influenced only by agriculture owing to the high inputs of phosphorus from detergents in wastewater.

More work is needed to prove the importance to *Hypnea* of nutrients, especially phosphorus, from cesspools and to determine if removing cesspools will reduce *Hypnea* growth. The four areas of *Hypnea* abundance in West Maui are adjacent to areas on land where cesspools are in use (Figs. 16a & 16b).

The amount of nitrogen supplied to nearshore waters by groundwater appears to be far greater than that needed to meet the growth requirements for *Hypnea*. Two lines of evidence support this conclusion that nitrogen is not a limiting nutrient for *Hypnea*. First, estimates indicate that groundwater supplies about twice the nitrogen, on a per kilometer basis, required to support the observed biomass of *Hypnea*.

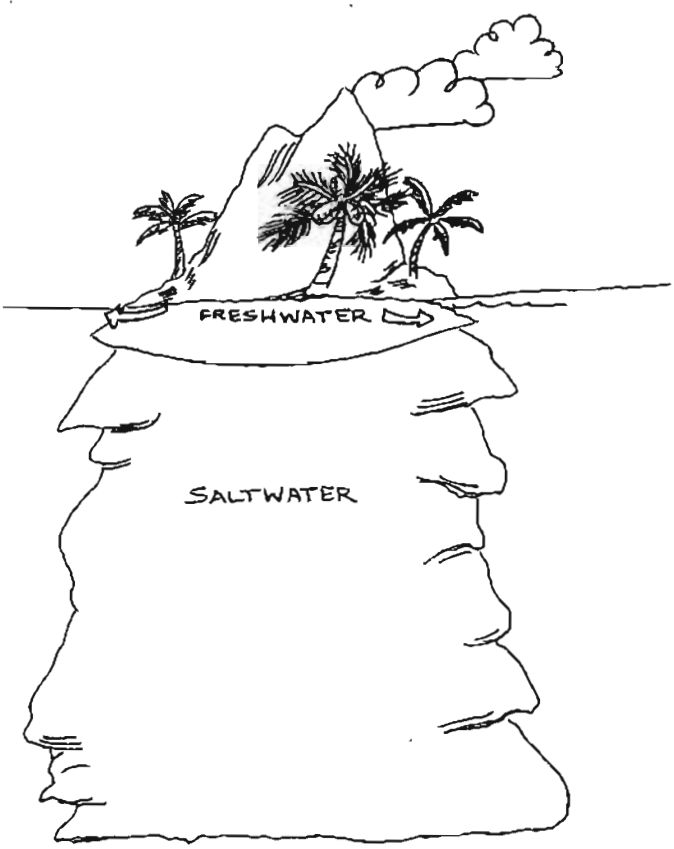

Figure 28. Fresh groundwater seeps into the ocean all along the shores of Maui as part of a natural process. The continuous seepage of ground water is the major source of nitrogen and phosphorus for *Hypnea* living in shallow water adjacent to the shore.

Second, using graphs of nutrient concentrations vs. salinity, it did not appear that uptake of nutrients by *Hypnea* reduces ambient concentrations beyond what could be explained by simple dilution.

Studies evaluated nutrients from oceanic currents, runoff from streams, and Lahaina's wastewater injection wells. While ocean currents and stream runoff bring nutrients to the areas where algae are thriving, these sources proved to be small when compared on an annual basis to inputs from groundwater (Dollar and Andrews, 1997).

The amount of nutrients available to *Hypnea* is related to nutrient flux, the product of water velocities and nutrient concentrations. Dollar and Andrews (1997) estimated that the low nutrient concentrations in open ocean water are far from sufficient to support the observed high biomass of *Hypnea*, even when water motion is taken into account.

Streams contribute large amounts of nitrogen, phosphorus, and sediment to the coastal waters for short periods of time after major rain events. Nutrient concentrations generally return to pre-storm levels within 5 days after the rainfall ends. Surface runoff and streamflow are probably not important sources of nutrients for *Hypnea* because the annual nutrient input from groundwater was 4 to 16 times greater than the total annual input from streams. Also, the areas of abundant *Hypnea* growth are not distributed at stream outlets and runoff occurs predominantly in winter, whereas the *Hypnea* is most abundant in summer.

Nutrients from the wastewater injection wells at the Lahaina Wastewater Reclamation Facility at Honokowai do not appear to contribute to the *Hypnea* bloom. There are no concentrations of *Hypnea* within a mile to the north or over 2 miles to the south of the Honokowai facility. Studies suggest that the injection well effluent seeps into the ocean floor over a large area and is highly diluted so that nutrient concentrations do not differ from those found in groundwater. Separate studies by TetraTech (1994), Bourke (1996), and Dollar and Andrews (1997) attempted to find the plume of wastewater in the area immediately offshore of the Facility at Honokowai. No significant high levels of nutrients were detected in the area offshore of the injection wells and the investigators concluded that there is no major "plume" of effluent seeping into the ocean within the immediate study area. The investigators never identified the plume's exact location and it is possible that the wastewater plume enters the ocean outside of the 1 km square study area immediately offshore of the Honokowai Facility.

Nutrient concentrations in the nearshore zone do not appear to be the sole cause of algal accumulations in West Maui. Inputs of nutrients associated with groundwater are presumed to be fairly uniform along the shoreline, although probably higher in areas of sugar cane than pineapple cultivation, and near cesspools. Yet the areas of high *Hypnea* abundance are very localized. In contrast to the West Maui findings, Dollar has shown that there are even higher concentrations of groundwater nutrients in the nearshore zone of West Hawaii, yet there are no reports of excessive algal growth in West Hawaii.

Dollar and Andrews (1997) hypothesized that the entire West Maui shoreline has sufficient nutrient concentrations, supplied by groundwater, to support *Hypnea* and that this alga may be limited in distribution by the availability of suitable habitat. They suggest that if this is the case, then land-based nutrient management, short of eliminating all human-related sources, is unlikely to have a major effect on *Hypnea* abundance. More experimental work is needed to demonstrate whether or not reducing nutrients from land, especially phosphorus, will have significant benefits in controlling *Hypnea*'s abundance in West Maui.

Causes of *Cladophora* blooms on Maui

We know less about the possible causes of the deep water *Cladophora* blooms that occurred in 1989 and 1991, because these blooms did not recur during the time of our research program.

Rainfall records for a 12-year period were reviewed by Stevenson (1997). The greatest rainfall occurred in April 1989 when the monthly total of 19.5 inches was nearly twice the highest monthly rainfall measured during all other months. The winter of 1990-91 was another very wet period. Both of these wet periods preceded summer blooms of *Cladophora* by a few months. The hypothesis that extreme rainfall triggered *Cladophora* blooms could not be tested directly because *Cladophora* did not recur.

Next steps with scientific research

As is the nature of scientific research, there are always questions that need more investigation. Many of the researchers' papers suggest topics for future research in addition to management approaches. In relation to the *Hypnea* blooms, further investigation is needed to determine:

- Whether phosphorus is a key limiting nutrient;
- Rates of recolonization and growth of *Hypnea* under field conditions;
- The role of nutrients from cesspools and other onsite sewage disposal systems; and
- Whether significant reductions of nutrient inputs from land would reduce or eliminate *Hypnea* blooms.

While much of what has been learned about *Hypnea* in West Maui is relevant to the algal blooms in Maalaea, Kihei, and Kahului, more specific investigations of these areas are needed. Tools developed by the West Maui research program can be applied in these other areas. A useful first step is to use the multispectral imaging technology to (1) identify the areas where *Hypnea* and *Ulva* are growing, (2) determine biomass or amount of algae present, and (3) use a Geographic Information System to map the algal population with potential nutrient sources in the watersheds (see Figures 16a & 16b).

In the event of another severe *Cladophora* bloom, research is needed to understand the causes of these blooms and to verify the hypothesis of Stevenson (1997) about the role of rainfall. Research needed in the event of a *Cladophora* bloom includes:

- Map the distribution of attached and drifting *Cladophora* using multispectral imaging;
- Quantify recent rainfall;
- Sample the *Cladophora* over its range to determine the species present;
- Measure growth rate of *Cladophora* in the field;
- Characterize the nutrient and temperature structure of the water-column in areas of dense growth;
- Assay alkaline phosphatase in algal tissues to gauge the degree of phosphorus limitation;
- Identify current patterns and how *Cladophora* is distributed by the currents.

The studies conducted as part of the Watershed Management Project provide a good baseline of information that is useful for characterizing present environmental conditions and for assessing future changes in water quality or algal distribution. However, these studies are not sufficient to assess long-term chronic degradation that may have occurred over the last decades or century. We recommend that a long-term coastal monitoring program be established

RESEARCH HIGHLIGHTS

The major source of nitrogen in nearshore waters is the continuous seepage of groundwater, enriched by the leaching of fertilizers.

In localized areas cesspools also contribute nitrogen and phosphorus to coastal waters where algae are abundant.

The contribution of nutrients from oceanic currents, stream flow, and wastewater injection wells at the Lahaina Wastewater Reclamation Facility were found to be less significant than nutrients from groundwater.

Availability of suitable habitat, water motion, lack of grazers, and a high growth rate in nutrient enriched waters likely combine to control *Hypnea* abundance.

that would identify good indicator measurements to integrate effects over time. This approach is necessary to determine long-term changes in water quality, structure of coral reef communities and fishery resources, and to assess the impacts of land use in the watershed and human use of marine resources. One example of a study designed to assess long-term changes using integrative indicator measurements is Brown and Forestell's (1995) report on the percent coverage of live corals and numbers of fish along transects at 4 coral reef sites in West Maui.

What's being done to control algae?

The West Maui Watershed Project recognizes the importance of improving erosion control and reducing the input to the ocean of nutrients from the watershed. The collaborative efforts of the Advisory Committee have helped make our coastal waters significantly cleaner than they were four years ago, and more improvements are underway.

The amount of nutrients and sediments reaching the ocean have been reduced. Improvements in sewage treatment and the irrigation of Kaanapali Golf Course with reclaimed water have cut nitrogen loads to sewage injection wells by over 60%. Twelve new sediment retention basins have been built to trap sediments before they reach the ocean, bringing the total to 23 sediment retention basins in West Maui's streams. More are planned.

Maui County is legally responsible for removing algal accumulations from beaches. The County has an ongoing program with contractors to remove algae from beaches in Kihei and Kahului Harbor.

Two new programs are being tested and show promise for providing more effective and cost-efficient removal of algal accumulations. Oceanit Laboratories Inc. is developing technology for removing drifting algae from the water. They will convert it into commercial products such as liquid fertilizer and potting soil. One product, "SeaSoil" is available now through Campaign Recycle Maui. The West Maui Taxpayers Association (WMTA) is working with Maui County to develop a "bounty" program to assist waterfront properties in removing algae. WMTA is matching youth groups who wish to raise funds with condos and parks where accumulations of *Hypnea* are a nuisance. The youth groups will be paid a "bounty" for every bag of algae they remove.

These management efforts minimize the excess nutrients that may contribute to algal blooms. They also improve the quality of coastal waters for recreational use and aesthetic purposes and help to meet conservation goals on agricultural lands. In West Maui where the visitor industry is the major sector of the economy, preserving the quality of our beaches, coastal waters, and local environment is essential to the community's economic well being.

TWO INNOVATIVE PROGRAMS SHOW PROMISE FOR MORE EFFECTIVE AND COST-EFFICIENT REMOVAL OF ALGAL ACCUMULATIONS:

1. **For information about removal of floating algae from the water and a new potting soil made from *Hypnea* called SeaSoil, call Bob Bourke at (808) 531-3017.**
2. **For information about the algae "bounty" program, call West Maui Taxpayers Association at 661-3042.**

Tasks to encourage algae clean-up and beneficial use

TASK 1. Develop more effective methods for removing algae from the shoreline. (MC, WMWMP)

Complete the pilot "bounty program" and modify to provide county wide services for cleaning beaches and rocky shores. (West Maui Taxpayers Association)

Complete test of Oceanit Laboratories' method for removing drifting algae.

Assess the feasibility and ecological impacts of removing *Hypnea* growing on rocks and study the rate of regrowth. If feasible, then encourage development of businesses to clean algae from rocks.

TASK 2. Monitor effectiveness of algae clean up and BMPs to protect water quality, and monitor the potential spread of algal problems. (DOH, WMWMP)

Oceanit Laboratories and West Maui Taxpayers Association evaluate the effectiveness of their new programs for removing algae from beaches and nearshore waters.

Repeat survey of hotels and condos (Cotton, 1996) to assess effectiveness of new programs for algae removal.

Continue Volunteer Coastal Monitoring Project beach surveys to track changes in algal accumulations over time and to watch for new blooms, i.e. *Cladophora.*

Use revised Dept. of Health water quality monitoring program to track and assess health of coastal waters in West Maui.

TASK 3. Encourage beneficial use of algae (MC)

Complete marketing analysis for algal-based products and test commercial viability of new products such as liquid fertilizer and potting soil. (MC, Oceanit Laboratories)

Educate Hawaii Organic Farmers Association, other businesses, and public about potential uses of algae.

Promote use of algae as compost ingredient along with sewage sludge, food waste, and/or green waste for commercial composting operations.

Promote use of *Hypnea* as food.

TASK 4. Promote increased numbers of herbivores in areas with abundant *Hypnea*. (DLNR)

Evaluate feasibility of a trap and spear fishing ban for some of the four sites in West Maui where *Hypnea* is abundant.

Evaluate options for increasing numbers of herbivores in areas where *Hypnea* is abundant, e.g. artificial reefs to enhance habitat, transplanting sea urchins.

References

(See Table 10 for an explanation of most citations from the text.)

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Table 11. Table of implementation responsibilities for encouraging algae clean-up and beneficial use.

DLNR-DAR	Hawaii Dept. of Land and Natural Resources, Division of Aquatic Resources
WMTA	West Maui Taxpayers Association
WMWMP	West Maui Watershed Management Project

	Dept. of Health	DLNR/DAR	Maui County	Oceanit Laboratories	WMTA	WMWMP
Complete research into causes of algal blooms	✓					✓
Objective 7. Encourage algae clean-up & beneficial use						
Task 1. Develop more effective methods for removing algae from the shoreline	✓		✓	✓	✓	✓
Task 2. Monitor effectiveness of algae clean up	✓	✓		✓	✓	✓
Task 3. Encourage beneficial use of algae	✓		✓	✓	✓	✓
Task 4. Promote increased numbers of herbivores in areas with abundant *Hypnea*		✓				

APPENDIX A

ACRONYMS

AWWA	American Water Works Association
BMPs	Best Management Practices
BWS	Maui County Board of Water Supply
COE	U.S. Army Corps of Engineers
CNPCP	Coastal Nonpoint Pollution Control Program
CZMA	Coastal Zone Management Act
DLNR	State of Hawai'i Department of Land & Natural Resources
DOH	Hawai'i State Department of Health
EPA	U.S. Environmental Protection Agency
LWRF	Lahaina Wastewater Reclamation Facility
MC	Maui County
mgd	Million gallons per day
ML&PC	Maui Land and Pineapple Company
MPC	Maui Pineapple Company
NMFS	U.S. National Marine Fisheries Service
NOAA	National Oceanic & Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System (Clean Water Act)
NRCS	U.S. Natural Resources Conservation Service
PMC	Pioneer Mill Company
PPP	Pollution Prevention Plan
TSS	Total suspended solids
TNC	The Nature Conservancy
UH	University of Hawai'i
USGS	U.S. Geological Survey
WMSWCD	West Maui Soil and Water Conservation District
WMWMP	West Maui Watershed Management Project

APPENDIX B

GLOSSARY

Alien species - Plant or animal species brought to Hawai'i by people, either purposely or by accident. Also known as exotic, introduced, or foreign species.

Anthropogenic - Related to man's activities.

Aquifer - An underground reservoir of fresh water which is often tapped for irrigation or drinking water.

Attenuation - To reduce in force or volume.

Best Management Practices - The most effective approach using the best available and most cost-effective technology to prevent or minimize pollution that might result from a particular activity.

Biomass - The weight of living material per unit area, or volume.

Brackish water - Slightly salty water containing dissolved minerals in amounts that exceed normally acceptable standards for municipal and domestic uses. Brackish water is considerably less saline than sea water.

Carrageenan - A colloid derived from certain marine algae. Used as a clarifying and stabilizing agent in foods.

Cesspool - An individual wastewater treatment system consisting of a covered pit or underground tank where wastewater is stored temporarily.

Check dams - Small dam constructed in a gully or other small watercourse to decrease the stream-flow velocity, minimize channel scour, and promote deposition of sediment.

Cladophora cerica - A green hair-like marine algae or limu. It occurs worldwide as a fast growing species typical of nutrient-rich waters. It may exhibit bloom and bust growth cycles, fluctuating in abundance. Large blooms of *Cladophora* occurred on Maui in 1989 and 1991.

Compost - A mixture of decayed organic matter used as a soil amendment.

Effluent - The treated liquid discharged from a wastewater treatment plant.

Endemic species - Plant and animal species which are native to Hawai'i, and are found nowhere else in the world.

Erosion - Wearing away of land surfaces by running water, wind and waves. Erosion occurs naturally from weather or runoff, but can be intensified by land-clearing practices related to agriculture, residential or industrial development.

Epiphyte - A plant or macroalgae living on another plant.

Exotic species - Plant or animal species that are not naturally found in Hawai'i. See alien and introduced species.

Grading - Any stripping, cutting, filling, stockpiling of soil, or combination thereof which modifies the land surface.

Groundwater - Underground water supplies stored in aquifers. Ground water is supplied by rain which soaks into the ground and flows downward, collecting in a distinct underground layer. Groundwater usually flows laterally toward a river, lake, or the ocean. Wells tap groundwater for consumptive uses.

Groundwater seeps - Areas along the coast where fresh water enters the ocean from an underground source, such as an aquifer.

Hazardous waste - A waste, or combination of wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics, may pose a substantial present or potential hazard to human health or the environment. Possesses at least one of four characteristics (ignitability, reactivity, corrosivity, or toxicity), or appears on special EPA or state lists.

Herbivores - Animals which eat exclusively plants or algae, such as grazing fish and some marine invertebrates.

Hydromodifications - Any alteration to a stream or coastal waters, whether it is a diversion, channel, dam or levee.

Introduced species - An alien, or exotic species which has been introduced to the Hawai'ian islands by humans, either intentionally, or unintentionally.

Leaching - The movement of soluble materials through soils by percolating waters.

Limiting nutrient - A nutrient such as nitrogen or phosphorus which controls the growth of a plant or marine algae.

Macroalgae - Marine algae which are larger than phytoplankton (> 1mm). Macroalgae are visible with the naked eye, such as *Cladophora* and *Hypnea* species.

Makai - Towards the ocean, or ocean side. Opposite from mauka, which means inland.

Marine sanitation device (MSD) - A complete system for handling human waste aboard boats or ships. Includes toilets (or "head"), holding tanks, macerators and discharge system.

Mauka - Towards the mountain, inland.

Multispectral imaging - A photographic technique which separates objects based on the spectra of light which they absorb.

Na Pale O Ke Kai - Defenders of the ocean. The name of the volunteer coastal monitoring project.

Native species - A plant or animal species which occurs naturally in an area. Not introduced by humans. May occur in other areas as well.

Nonpoint source pollution - Pollution that originates from a dispersed source, e.g. runoff, rather than from a pipe or point source discharge.

Phytoplankton - Microscopic plants which float in the water, such as diatoms and dinoflagellates.

Pollution prevention - Pollution prevention means minimizing the amount of waste products and pollution generated. Some examples include: conserving water and electricity, minimizing the use of fertilizers and pesticides, and reducing polluted runoff from agriculture, urban areas, and building sites. A proactive approach of preventing pollutants of any kind from reaching the environment.

Pump-out station - A land-based sewage retrieval pump used by boaters to discharge marine sanitation effluent. The pump-out station on the north side of the Lahaina Harbor loading dock is connected to the county sewer system.

Reclaimed water - Refers to treated wastewater, suitable for use in landscape and agricultural irrigation. Recycled water.

Residence time - The period of time required for water in one area or bay to exchange with other water.

Riparian area - Vegetated ecosystems along the edge of a water body. Riparian areas characteristically have a high water table and are subject to periodic flooding.

Sediment - Sediment is the result of erosion. It is the solid mineral and organic material that is transported in suspension, or has been moved from its site of origin by wind or water.

Sediment retention basin - A depression formed by the construction of a barrier or dam built to retain sediment, rock, gravel, sand, silt or other materials.

Substratum - A surface on which a plant or animal grows or is attached.

Turbidity - A measure of the amount of material suspended in the water. Increasing the turbidity of the water decreases the amount of light that penetrates the water column. Sustained high levels of turbidity are harmful to marine life. Measured in Nephelometric Turbidity units (NTU).

Ungulates - Hoofed animals such as cattle, sheep, deer, pigs, and horses.

Vegetative buffers - Strips of vegetation separating a water body from a land use; with potential to reduce nonpoint pollution.

Wastewater injection well - A well with a perforated casing used to dispose of treated wastewater into the ground.

Watershed - A term used to describe the land area that is drained by a particular stream and includes the water resources (lakes, streams, wetlands, and groundwater) in that drainage basin. A watershed is parallel to the Hawaiian concept of ahupua'a.

APPENDIX C

ROLES OF GOVERNMENT AGENCIES IN WATERSHED MANAGEMENT

Government roles in agricultural erosion control

U.S. Army Corps of Engineers

Construct new sediment retention basin at Kahoma Stream by converting existing debris basin.

Issue Clean Water Act Section 404 permits for sediment retention basins.

Hawaii Department of Health

Promote the development and testing of new erosion control BMPs through Clean Water Act 319 grants.

Assist in the development and review of Pollution Prevention Plans for pineapple, sugar, and coffee agriculture.

Participate in training program on soil erosion and sediment control.

Respond to complaints about erosion at construction sites within 3 days and notify person filing complaint of findings and actions taken.

Keep District Health Office informed of NPDES General Construction Activities Storm Water Permits. Inspect all major permitted construction sites at least once during construction, in rainy season if possible.

Where clear violations result in public complaints and environmental damage, take aggressive enforcement action and issue a press release announcing penalties.

Exchange information about complaints and inspections with Federal and County inspectors and with the Soil and Water Conservation Districts, as appropriate. Schedule joint inspections where possible and share follow-up responsibilities.

Maui County (Dept. of Public Works and Waste Management)

Assist in the planning and permitting process for construction of sediment retention basins at Honokeana, Kaopala, and Kahoma.

Assure regular cleaning and maintenance of sediment retention basins at Napili 4-5, Kahana, Mahinahina, Honokowai, and Kahoma Streams.

Where possible, link sediment removal with need for fill by local construction projects to reduce costs.

Participate in training program on soil erosion and sediment control.

Revise soil Erosion and Sedimentation Control Ordinance to provide a comprehensive framework for requiring the control of sediments and other pollutants in runoff from construction sites.

Issue grading and grubbing permits.

Develop a comprehensive training program for inspectors and the development community.

Develop a manual of BMPs for erosion control at construction sites specifically designed for local conditions in Hawaii.

Develop a clear simple brochure describing the revised grading ordinance and how to apply for a grading/grubbing permit.

Respond to complaints about erosion at construction sites within 3 days and notify person filing complaint of findings and actions taken.

Inspect all major permitted construction sites at least once during construction, in rainy season if possible.

Where clear violations result in public complaints and environmental damage, take aggressive enforcement action and issue a press release announcing penalties.

Exchange information about complaints and inspections with Federal and State inspectors and with the Soil and Water Conservation Districts, as appropriate. Schedule joint inspections where possible and share follow-up responsibilities.

Evaluate potential for giving County inspectors authority to issue citations with penalties on site for clear permit violations.

Natural Resource Conservation Service

Develop and update soil conservation plans for pineapple, sugar cane and coffee fields in order to continue and expand the use of combinations of erosion control BMPs. Target drainage basins upland from "high turbidity areas" for improved erosion control.

Schedule field inspections with the plantation superintendent to identify vulnerable areas and set priorities for maintenance. Inspections during the rainy season will help to identify problem sites and needed repairs. Focus attention primarily on roads and other vulnerable areas.

Participate in the development and testing of new erosion control BMPs to reduce erosion in areas with high runoff volumes, including roads and fields planted within the last 12 months.

Assist WMSWCD with development and review of Pollution Prevention Plans for pineapple, sugar, and coffee agriculture.

Assist in development of vegetative buffers between fields and streams and assist in restoration of riparian vegetation along stream banks.

Evaluate the potential for deepening or widening basins without impairing the structural integrity of the dams.

Evaluate the feasibility of adding new basins in series to improve sediment retention.

Participate in developing and promoting revisions to Maui County Erosion and Sedimentation Control Ordinance.

Participate in comprehensive training program for inspectors and development community.

Assist in development of a BMP manual for erosion control at construction sites, specifically designed for local conditions in Hawaii.

West Maui Soil and Water Conservation District

Review and approve soil conservation plans for pineapple, sugar, and coffee. Target drainage basins that are upland from "high turbidity areas" for aggressive erosion control.

Participate in the development and testing of new erosion control BMPs to reduce erosion in areas with high runoff volumes, including roads and fields planted within the last 12 months.

Oversee development of Pollution Prevention Plans for pineapple, sugar, and coffee agriculture.

Assist in development of vegetative buffers between fields and streams and assist in restoration of riparian vegetation along stream banks.

Support the construction of new sediment retention basins at Honokeana and Kaopala.

Evaluate the need for cleaning and maintenance of basins on an annual basis and notify County of Maui Department of Public Works and Waste Management of cleaning needs each spring.

Participate in developing and promoting revisions to Maui County Erosion and Sedimentation Control Ordinance.

Review and comment on drainage and erosion control plans and submit comments to Maui County.

Participate in comprehensive training program for inspectors and development community.

Assist in development of a BMP manual for erosion control at construction sites, specifically designed for local conditions in Hawaii.

Inspect all major construction sites at least once during construction, in rainy season if possible.

Where clear violations result in public complaints and environmental damage, take aggressive enforcement action and issue a press release announcing penalties.

Exchange information about complaints and inspections with State, Federal and County inspectors, as appropriate. Schedule joint inspections where possible and share follow-up responsibilities.

West Maui Watershed Management Project

Organize a team of erosion control experts from University of Hawaii, Agricultural Extension Service, and NRCS to "brainstorm" potential new BMPs that may be effective in West Maui to reduce erosion in areas with high runoff volumes.

Provide funding to improve erosion control in West Maui.

Collect data through volunteer coastal monitoring program to identify and rank "high turbidity areas."

Track the construction of new sediment retention basins and the amount of sediments removed from basins, and report results to the community.

Participate in developing and promoting revisions to Maui County Erosion and Sedimentation Control Ordinance.

Government roles in preventing pollution

Hawaii Department of Land and Natural Resources, Division of Boating and Ocean Recreation

Distribute brochure "What Boaters Can Do to be Environmentally Friendly" with Harbor billing.

Provide a bulletin board for signs and boating information at Mala Wharf.

Add signs and instructions for oil recycling barrels.

Apply for State and federal funding to install additional pump-out facility on south side of Lahaina dock.

Provide signs and instructions for use of existing pump-out facility.

Continue to improve restroom facilities at Lahaina Harbor to encourage use of Harbor restrooms over marine toilets.

Hawaii Department of Health

Participate in workshops on what boaters can do to prevent pollution.

Take enforcement action for illegal discharges to marine waters.

Monitor coastal water quality on an ongoing basis to establish a baseline of existing conditions and problems and to characterize damage associated with illegal discharges and spills.

Maui County

Develop a household hazardous waste disposal and educational program for Maui County, including drop-off program for paints, pesticides, and other hazardous waste.

Consider the feasibility of instituting a "leash law" for the urban areas of Maui County.

Develop an educational program for Maui's businesses on stormwater pollution prevention.

Construct new public restroom facilities on Front Street by Lahaina Public Library.

Cooperate in planning and construction of additional pump-out facility at Lahaina dock.

Natural Resources Conservation Service

Assist in the development of agricultural pollution prevention plans, including plans to improve the use and efficiency of best management practices for agricultural fertilizers.

Assist in development of precision agriculture in area of fertilizer use on Maui.

U.S. Coast Guard

Enforce equipment requirements for marine sanitation devices.

Complete Geographical Response Plan for hazardous spills for West Maui area.

Direct oil spill response efforts and investigate pollution.

Train local boaters in oil spill response and develop community response team.

Require waste management plans for vessels over 40 feet, describing procedures for collecting, storing, and disposing of garbage.

Enforce Marpol Annex I & V Requirements for oil and waste management.

West Maui Watershed Management Project

Distribute brochure: "Island Stewardship: Guide to Preventing Water Pollution for Maui's Homes and Businesses."

Develop educational programs on video, TV, and Internet based on Island Stewardship guide.

Develop a pollution prevention training and certification program for Maui's hotels, condos, golf courses, and landscapers.

Distribute brochure: "What Boaters Can Do to Be Environmentally Friendly."

Participate in workshops to discuss what boaters can do to prevent pollution.

Distribute information to boat crews about environmentally friendly products for boat cleaning and maintenance.

Government roles in algae clean-up and beneficial use

Hawaii Department of Health

Oversee studies needed to complete research into causes of algal blooms in West Maui and expand research to other areas with algal problems such as Kihei and Kahului.

Oversee successful completion of Oceanit Laboratories pilot project for methods of removing algae and developing commercially valuable products.

Assess feasibility and ecological impacts of removing *Hypnea* growing on rocks and study the rate of regrowth.

Continue Volunteer Coastal Monitoring Project and link methods and results with Clean Water Branch water quality monitoring.

Promote use of algae as a compost ingredient along with sewage sludge, food waste, and/or green waste for commercial composting operations.

Hawaii Department of Land and Natural Resources

Evaluate feasibility of a fishing ban for the four sites in West Maui where *Hypnea* is abundant.

Evaluate options for increasing numbers of herbivores in areas where *Hypnea* is abundant, e.g. artificial reefs to enhance habitat, transplanting sea urchins.

Maui County

Continue to provide services for cleaning nuisance algal accumulations from beaches.

Continue to encourage more efficient approaches for cleaning beaches.

Complete the pilot "bounty" program and modify to provide county wide services for cleaning beaches and rocky shores.

Educate farmers, businesses, and public about potential uses of algae.

Promote use of algae as compost ingredient along with sewage sludge, food waste, and/or green waste for commercial composting operations.

West Maui Watershed Management Project

Complete research into causes of algal blooms and communicate research findings to public.

Educate farmers, businesses, and public about potential uses of algae.

Continue Volunteer Coastal Monitoring Project beach surveys to track changes in algal accumulations over time and to watch for new blooms.

Repeat survey of hotels and condos to assess effectiveness of new programs.

APPENDIX D

COMMUNITY COMMENTS ON THE WEST MAUI WATERSHED OWNERS MANUAL

(from community workshops held August 12 and 14, 1997)

What about the Owners Manual works or helps?

Makes people aware of issues.

Proactive rather than reactive.

Concept of education for young and old.

Focuses on the big picture, comprehensive.

Back cover has good, straightforward, visible ideas for protecting the ocean.

Opened lines of communication between stakeholders, new spirit of cooperation.

Represents all stakeholders, balanced perspective.

Stakeholders learned to respect one another.

Actually a concrete product, all information in one place.

Specific recommendations, simple yet comprehensive, gives hope, inspires.

Sincere thanks to the stakeholder committee.

Creative incentives to get people involved.

Recognizes the need for action to protect the environment.

Something for everyone.

Volunteerism and community-based.

Will (may) educate government officials.

Laudable focus.

What would you add or change about the Owners Manual?

Natural sediment retention basins are being destroyed by development and need to be preserved.

Incorporate water management training into school curriculum.

Establish a cadre of volunteer trainers to go out to schools and send information home, kids will teach parents.

Include a tear out volunteer application form, also have space for concerns and suggestions to be submitted by mail.

Add more positive incentives for compliance.

Need to demonstrate where the wastewater plume goes into the ocean.

The Soil and Water Conservation Districts (SWCDs) can help get educational materials and training out to schools and community.

Teachers need to be trained to use educational materials.

Make an effort to build on work of SWCDs and expand efforts to include Hana and Olinda/Kula Districts. SWCDs can raise money.

Need incentive for boats to use wastewater pump out facility. Examples include returning % of taxes for boats that use it or provide a sticker or certification that businesses can use in advertising.

Need more wastewater pumpout facilities at Harbors; there is none at Maalaea.

Need a technical assistance program or funding to help boat owners install hardware so they can use pumpout.

Use the MECO incentive program for solar panels and shower heads as models for other incentives.

County should provide matching funds or share costs to help communities invest in infrastructure for reclaimed water use. Condo and home owners who would like to use reclaimed water cannot because it isn't cost effective.

The reclaimed water system is flawed because there isn't adequate storage. We need a reservoir at lower elevation where pumping costs will be reasonable, e.g. 200 feet above highest user. The County and State should take responsibility for this funding.

An injection well at 180 feet deep is actually considered shallow; recommend a well depth minimum of 1000 ft.

Chapter 5, Native Forests says to "avoid planting invasive plants." A list of examples and pictures of invasive plants should be included.

Incorporate a County complaint form that can be submitted by mail into the Owners Manual.

Put chapter identification headers on each page.

Reorganize chapters so that their numbering corresponds with the number of the Objective being addressed.

In Chapter 5 provide contact information for local experts on native plants.

Where is the accountability for results? This should be a published part of Owners Manual.

Consider a community-based litigation/ consequence process. Develop public awareness of violations and violators.

Educate potential violators.

There is a need to enforce existing laws.

Swimming pool water should be recycled, no ocean dumping.

Identify limitations on % coverage of impervious surfaces for new development.

Maintain natural flood plains and drainageways.

Provide a map showing locations of existing and former wetlands.

Promote native Hawaiian riparian systems, taro agriculture and other Hawaiian practices.

Need baseline data for environmental concerns so that impact and progress can be measured.

Where do we go from here?

Present Owners Manual to Mayor and all administrative assistants.

Do briefings on the Owners Manual for the Planning Commission and Director of Planning.

Work to encourage support for the new grading ordinance being proposed.

The new watershed coordinator should have grant writing skills and the position should be full time if the program is to be effectively administered as well as expanded Island wide.

The stakeholders involved in the project should help select the new coordinator.

Work should begin now on future funding.

Grant money is needed for enforcement.

Educate businesses and landowners, as well as the community.

Educate newcomers to Hawaii's environmental uniqueness.

Have more workshops to consider projects of the future.

Expand to include other watershed areas.

Need County leadership to ensure continuity.

Do cost/benefit analysis of various solutions.

Brainstorm with the native Hawaiian community on the issues addressed by the study.

Put the Owners Manual on the Internet and open it to electronic discussion.

Get information out to "Knife and Fork Clubs," outreach to business community.

The following letters were submitted by West Maui Watershed Advisory Committee Members in regard to the points of debate described on page 21.

LINDA LINGLE
Mayor

CHARLES JENCKS
Director

DAVID GOODE
Deputy Director

RALPH NAGAMINE, L.S., P.E.
Land Use and Codes Administration

EASSIE MILLER, P.E.
Wastewater Reclamation Division

LLOYD P.C.W. LEE, P.E.
Engineering Division

Solid Waste Division

BRIAN HASHIRO, P.E.
Highways Division

COUNTY OF MAUI
DEPARTMENT OF PUBLIC WORKS
AND WASTE MANAGEMENT
200 SOUTH HIGH STREET
WAILUKU, MAUI, HAWAII 96793

September 2, 1997

Wendy Wiltse, Ph.D.
West Maui Watershed Coordinator
Lahaina Comprehensive Health Center
1830 Honoapiilani Highway
Lahaina, HI 96761

Dear Dr. Wiltse:

SUBJECT: **NEED FOR FURTHER RESEARCH ON INJECTION WELLS**

The County of Maui believes that additional research to determine the exact location of where effluent from the injection wells enters the ocean environment is not warranted. Multiple studies conducted as part of the West Maui Watershed project found that the effluent does not discharge as a plume into the near shore waters and concluded that there was no correlation between effluent injection well use and the algae blooms.

Nevertheless, the Wastewater Reclamation Division of the County of Maui has acted responsibly by implementing various strategies to minimize the impact of injection well use. These actions include:

1. The addition of nutrient removal capability at the Lahaina and Kihei Wastewater Reclamation Facilities. These systems are removing over 40% of the nitrogen in the effluent thus reducing the nutrient load to ground water.

2. Aggressive promotion of wastewater reuse. Currently, close to 42% of the reclaimed water from the Kihei WWRF is reused and 20% of the reclaimed water from the Lahaina WWRF is reused. These figures will increase as more and more water reuse projects come on line. The County is also the only county in the state of Hawaii to mandate the use of reclaimed water at commercial properties that are in close proximity to reclaimed water distribution systems. As more wastewater is recycled, less will be disposed of via injection wells.

3. The administration of water conservation plumbing retrofit programs. The Wastewater Reclamation Division has been the driving agency behind water conservation programs in the County. Our goal is to reduce the volume of wastewater to be treated and disposed of via injection wells. We co-funded the Maui Electric Company showerhead program and have retrofitted several affordable housing multi-family complexes with water saving toilet flappers. We also will be partnering with the Board of Water Supply to distribute these toilet flappers to single and multi-family residences to save water and reduce wastewater generation.

While further research on injection wells may provide further insight on the ultimate fate of wastewater effluent, we feel that the funds required for such research would be better spent for the expansion of our reclaimed water distribution systems and/or for the funding of water conservation plumbing retrofit programs.

Thank you for the opportunity to express our viewpoint on this important issue. Should you or any other readers have any questions or comments, please call Tracy Takamine at 243-7417.

Sincerely,

FOR Charles Jencks
Director of Public Works
and Waste Management

SP:97253.reu

GLENN L. SHEPHERD, Ph. D.
GEOLOGIST- MOSTLY RETIRED

447 SOUTH ALU ROAD
WAILUKU, MAUI, HAWAII 96793
U. S. A.
TEL : (808) 244 7224 FAX : (808) 242 2909

4 September, 1997

Dr. Wendy Wiltse
West Maui Watershed Coordinator
Lahaina Comprehensive Health Center
1830 Honoapiilani Highway
Lahaina, HI 96761

Dear Dr. Wiltse:

I cannot locate the cross-section I made a couple of years ago that extended from the injection plant to the offshore near Honokowai Point. (Do you have it?) Nevertheless, it could be reconstructed from County of Maui Department of Public Works and Waste Management data. From memory, the cross-section showed that injected effluent would discharge at a depth from about 20 to 50 feet offshore in a line from the Lahaina injection wells. How the effluent travels is unknown, but certainly along the very porous and permeable clinker lava beds. These can be referenced from the quarry just uphill from the injection wells, which dip at an average of 1 1/2 degrees toward the edge of the island.

Tetra Tech`s rhodamine dye tracer exercise showed rather spotty and inconclusive results. This may be due to using the wrong type of tracer; rhodamine may be adsorbed by the rocks and clays with which it comes in contact. Or,simply, it is not detected in the ocean because of technique or dilution factors. I do not know whether Oceanit tested for dye tracer in the ponds and wetlands behind the dune system along Kekaa or makai of the old Kaanapali Airport, but that is a possibility.

A hard correlation between injected effluent and unwanted algae blooms is not proven. However, the Lahaina effluent, which purportedly has some 30-40 % nitrogen removed, may have the added amount which triggers a bloom at preferential seasonal temperatures of the inshore waters. Common sense dictates that added nutrients (N) above ambient levels of inshore waters increases the likelihood of a continuing but fluctuating bloom over time.

In my view, it is important to know where the effluent is going, and that we do not know. A study using short-lived radioactive tracers added to the effluent injected into the wells is much more sensitive to detection. Cost should be minimal. A couple of years ago, I forwarded to you a letter from an engineer from Unocal, the largest operator in Geysers geothermal field in Northern California. Radioactive tracers have been used successfully for many years in geothermal and oilfield practices. It is imperative for them

to know where their fluids are going. The engineer said he would give his assistance in a survey on Maui.

The very word "radioactive" incites the imagination of the uninformed. However, the level of radioactive material used is not much more than that on the dial of my watch which you have sat next to for hours and which I have worn for 50 years.

There is a perceptual aspect which is very important; tourists and residents alike would take a dim view of waste effluents entering the immediate coastal waters where they indulge in watersports. Though the content and chemistry of the effluent is thought to be harmless, I believe we are still low to mid-point on the learning curve in what it can do to the environment along with possible sneaky pathogens. So, I personally believe it is worth the effort to know where the effluent is going and if it is going to the wrong places, to correct the situation.

I have always been a proponent of deeper injection wells to increase the likelihood of dispersing effluents farther offshore, given the dip of the lava beds and the cumulative effect of layered volcanics. Mixing of effluent in the fresh water lens is also avoided with properly cased deeper wells.

I suggest:

1. A short-lived radioactive tracer study of effluents from the Lahaina wastewater plant since previous studies were inconclusive.

2. Deeper injection wells to direct effluents much further offshore as dictated by tracer studies.

Aloha,

Glenn L. Shepherd

Glenn L. Shepherd

P.S. Thank you for your dedication. I wish you well in your new endeavors.

cc: Charlie Jencks, Director and David Goode
Dept. of Public Works and Waste Management
County of Maui

The Watershed Committee met for its final session under the leadership of Wendy Wiltse on September 3, 1997. The group could not agree on the statement concerning whether increased nutrients from land-based-runoff was associated with the nuisance algal blooms.

My understanding of the creation of the1989 and 1991 nuisance algal blooms of cladorphora and hypnea in West Maui is based on several events. Hypnea was introduced into Kaneohe Bay, Oahu for the production of agar in the late 1970's. Cladorphora had been found in small amounts throughout the island chain since the late 1960's. Small amounts of hypnea and cladorphora can be found in underwater videos in 1967-87 throughout West Maui's waters from the shoreline to 50 ft. depths. In the summer of 1989 a few pounds of hypnea and cladorphora had bloomed into hundreds of tons in W. Maui.

Several events were observed at this time. First, sugar-cane land in the area above the algal bloom-infested waters were cleared for the first planting of pineapple. Sewage spills had entered the ocean and ocean temperatures were consistent at 79 F. and wave action was gentle. These conditions are ideal for algal growth: fertilizer from agriculture runoff and nitrogen from sewage, warm water and gentle wave-action. The presence of nuisance algae in small amounts in the ocean from Kapalua to Honokawai for 10-20 years prior to the algal blooms, suggests that these changes leading to the ideal growing conditions in 1989 and 1991 allowed for the algae's tremendous growth.

Sediment basins, improvements to the wastewater treatment facility, new sewage pipes. have all been implemented in West Maui. As a result, many once algae-infested areas, now have algae growth in balance. Some areas continue to have episodic occurrences of hypnea and ulva. These areas provide ideal growing conditions and the hypnea and ulva have taken root and dominate. Cladorpora remains in balance with other algal species.

Though much debated, I favor the clean-up of the dominant algae, since it is here to stay. I do not support spending more money to study how the algae came to dominate these areas. This can be explained by the nature of hypnea and ulva - both are species that grow rapidly in ideal conditions and reproduce in greater volume than can be eaten by turtles or fish. Hypnea and ulva (sea lettuce) can be compared to weeds growing in a field.

The research attempts to find where nutrients were leaching into the ocean were preliminary and the results were inconclusive. The researchers requested that more studies be conducted and such studies will be forthcoming. I recommend that the hypnea, ulva and cladorphora be monitored and records be kept on their the growth patterns and the conditions under which they occur. I strongly support that the algae be removed from the ocean and beaches as mandated by State laws in order that all beaches and the near-shore ocean can be made usable for residents and visitors alike. Removal of the algae will help the reefs to return to their natural state and beaches restored to their natural beauty.

to be

Respectfully submitted Eve Clute

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August 25, 1997

Dr. Wendy Wiltse
West Maui Watershed Coordinator
West Maui Watershed Management Project
Lahaina Comprehensive Health Center
1830 Honoapiilani Highway
Lahaina, HI 96761

Dear Wendy:

Once again we would like to thank you for all of your effort in coordinating the West Maui Watershed Project and assembling the Owners Manual. We are proud to have been a part of this effort and hope that the manual will inspire improved management of the natural resources in the West Maui watershed. Our organization is committed to the principles of agricultural best management practices, many of which are included in the manual, and will continue to advocate for their use.

The following are our comments on the July 1997 draft of the West Maui Watershed Owners Manual.

Although we are pleased with the manual in general, the Hawaii Agriculture Research Center (HARC) continues to have concerns with regard to the manual's obfuscation of the fact that no definitive connection has been established between elevated levels of nutrients and the abundance of algae. In fact, although a careful reading of the scientific research done for this project reveals a glaring gap in the data, the statements in the manual point toward the conclusion that anthropogenic sources (specifically agriculture) cause algae "blooms." This conclusion is unwarranted.

This manual arose out of community-based concern over the causes and solutions to the algae problems along the West Maui shoreline. The project was an effort to promote *voluntary* watershed management activities and provide incentives for their application while protecting the economy, aesthetics and diversity of the community. While the principal use of the manual is to target pollution prevention activities to improve coastal water quality, the sugar industry is concerned that the manual will be used as a regulatory tool to establish an enforcement program at the state and/or county level. This would be a most inappropriate use since we still do not know the cause of the algae problem and whether or not any of the recommendations made in the manual will in fact have any effect on the problem. However, as evidenced by the August 14 public meeting in which various participants advocated lawsuits, citizen attorneys general, and enforcement provisions, this message clearly did not come across to the public.

HARC believes that without changes to the manual, the public may be deceived into believing that a cause has been found and that the solution may be as simple as more regulations and more enforcement. As you know, we disagree with this approach and with some of the theoretical numbers tendered in the research and do not believe they should be represented in the manual as facts (nor from which to draw conclusions upon which regulations may be based in the future).

The placement of certain statements, phrased as conclusions, are equally disturbing and inappropriate. The following are examples of this:

In the **Summary, p. ii, Research findings and recommendations**-"The major source of nutrients supporting the growth of Hypnea is the steady seepage of groundwater along the shore." This statement misleads the reader in thinking that groundwater nutrients are necessary to support Hypnea growth. While it is true that groundwater is thought to be a major source of nutrients to the coastal waters, we still do not know if the Hypnea is using these nutrients or needs them to thrive.

In the section entitled, **Causes of Hypnea Blooms on Maui, p. 70**-"About 87% of the nitrate in groundwater results from the leaching of fertilizers applied to large-scale agriculture." We have previously discussed with you our misgivings about the model used to predict this number. Models can produce numbers only as good as the data supplied to them. In this case, the limited, and in some cases flawed, data do not serve as a reliable basis from which to predict nutrient loading estimates. Certainly, if these numbers are proffered, the manual should include a discussion of the limitations of the studies used to generate them.

Within the section entitled, **Reduce soil erosion throughout the watershed, p. 20**, we suspect that the average layperson will miss the significance of numbers within parentheses. The numbers indicate the area of land use monitored by the runoff study. For sugarcane, only 1.8 acres of land out of a total of approximately 5,500 acres in cane were represented. Because of the paucity of data, the figures for sediment and nutrient loads are not statistically reliable and should not be used to create nutrient load trend data by land use (page 21), or should be represented only in light of the limitations of the data.

HARC would like to see the facts outlined in the following two paragraphs from page 72 more prominently incorporated into the manual, optimally within the summary. An understanding of these facts is critical to a realistic perspective on the entire algae problem.

> Nutrient concentrations in the nearshore zone do not appear to be the sole cause of algal accumulations in West Maui. Inputs of nutrients associated with groundwater are presumed to be fairly uniform along the shoreline, although probably higher in areas of sugarcane than pineapple cultivation, and near cesspools. Yet the areas of high Hypnea abundance are very localized. In contrast to the West Maui findings, Dollar has shown that there are even higher concentrations of groundwater nutrients in the nearshore zone of West Hawaii, yet there are no reports of excessive algal growth in West Hawaii.
>
> Dollar and Andrews (1997) hypothesized that the entire West Maui shoreline has sufficient nutrient concentrations, supplied by groundwater, to support Hypnea and that this alga may be limited by the availability of suitable habitat. They suggest that if this is the case, then *land-based nutrient management, short of eliminating all human-related sources, is unlikely to have a major effect on Hypnea abundance* (italics added). More experimental work is needed to demonstrate whether or not reducing nutrients from land, especially phosphorous, will have significant benefits in controlling Hypnea's abundance in West Maui.

Inasmuch as watershed management may involve the reallocation of financial resources, care must be taken to ensure that the public understands the nature of the problem and the limits to our understanding of it. Solutions, in addition to being politically popular, must also be technically correct. Although the manual itself does not necessarily promote more regulation of agricultural practices, we are aware that this idea has been entertained by some within the Hawaii Department of Health. Because of the lack of sufficient data and the uncertainty about specific causative factors, regulatory efforts such as limitations on nutrient loading, would be premature and should be postponed until the data gap is bridged.

Thank you for the opportunity to comment.

Sincerely,

Janet Ashman
Environmental Specialist

c: Dennis Lau, Department of Health Clean Water Branch

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September 2, 1997

Dr. Wendy Wiltse
West Maui Watershed Coordinator
West Maui Watershed Management Project
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Lahaina, HI 96761

Dear Wendy:

I wanted to take this opportunity to comment on an issue of great concern to me regarding the interpretation and the potential misuse of data presented in Dollar and Andrews (1997) *Algal Blooms off West Maui: Assessing Causal Linkages between Land and the Coast Ocean, Final Report.* Correct interpretation and use of these data are important in developing appropriate management measures for the West Maui Watershed.

In Table 19 of this report, the authors examine the nutrient requirements for *Hypnea* production and compare those requirements to the general magnitude of nutrient input from groundwater flux (natural plus agricultural subsidies), cesspools, and coastal oceanic waters. Nutrient requirements for *Hypnea* production and nutrient inputs are examined in two different manners.

The first approach utilizes a simple box model. Total nutrient inputs along the entire 35 kilometer study area are compared against nutrient requirements for all *Hypnea* in the study area. This model requires an assumption that 100 percent of the nutrient inputs along the entire coastline (35 kilometers) are potentially available to *Hypnea* even though this alga is limited to 3 kilometers or less than 10 percent of the shoreline. The authors reach the conclusion that "...for the total coastline, using the growth rate of 10% per day, there appears to be far more N and P supplied to the coastal ocean in groundwater than is required to support the observed biomass" (page 25 and 26).

The assumptions required to reach this conclusion are completely unrealistic and lead to an inappropriate assessment of the potential impacts of land-based sources of nutrients. It is impractical to 1) expect longshore transport to result in exposure of *Hypnea* to all groundwater inputs within the study area and that 2) 100 percent of these nutrients would be available for algal production. On the average, *Hypnea* is found within five meters of the shoreline and at depths of less than one meter. In 1996 progress reports compiled by the West Maui Watershed Management Project, Dollar (1996) estimated a very rough residence time of one hour for waters within 50 meters of the shoreline with an average depth of one meter. This estimate, as well as field measurements reported by Dollar and Andrews, indicate that groundwater sources of nutrients are likely to disperse rapidly out of the nearshore habitat occupied by *Hypnea*. It is highly unrealistic to assume that nutrients from groundwater sources will be retained in the nearshore zone, transported tens of kilometers, and be 100 percent available to algae that occupy 10 percent of the coastline.

The second approach provides a more realistic assessment but, in my opinion, still leads to potential misinterpretations based upon assumptions that 100 percent of the nutrients are available for algal production. This analysis examined nutrient requirements for *Hypnea* production and nutrient inputs on a per kilometer basis. This led to the following conclusion from page 26 of the Dollar and Andrews report:

> Based on these estimates, if it were possible to separate groundwater nutrient components, and to prevent lateral mixing of water in (the) ocean, it appears that specific regions of algal growth could be supported by agriculturally subsidized groundwater or high-density cesspool usage. Algal abundance could not be supported solely b natural groundwater input or low cesspool density. These results are in contrast to the estimates based on the total coastal input, which indicated that algal biomass could be supported by natural groundwater input.

Indeed, this second, more realistic approach suggested that natural groundwater sources of N and P could provide only 25% of the nutrients necessary to support *Hypnea* production of 10 percent of the standing stock per day.

Another potential problem exists regarding the loading rates used for N in groundwater from natural sources. The authors used data from Soicher and Peterson (1997) for the groundwater loading rates. This report contains conflicting information. In the body of the report (page 80), Soicher and Peterson state that natural volumes of recharge to the basal lens from the dike zone above the sugar fields supply 11,260 kg-N/yr. This same number is used in the conclusions to represent the total loading rate for natural groundwater for the entire study area. Dollar and Andrews (1997) have assumed that the 11,260 kg-N/yr applies only to 16.8 km of coastline below land used for sugarcane production instead of the entire 35 km of shoreline included in the study. If the groundwater load should, in fact, be applied to the entire 35 km, natural groundwater sources would represent as little as 10 percent of the nutrient requirements for *Hypnea*.

Instead of suggesting that "land-based nutrient management, short of eliminating all human-related sources, is unlikely to have a major effect on *Hypnea* abundance", data presented by Dollar and Andrews (1997) provides the strongest case that more effective management of land-based nutrients has the potential to control *Hypnea* abundance. Nevertheless, this simple model only provides a crude assessment of the significance of various sources of nutrients and still requires some very substantial assumptions. As the authors suggest, more experimental data would be necessary to demonstrate if reduction of land-based nutrients would have significant benefits in controlling abundance of this alga in West Maui.

I appreciate the opportunity to comment.

Sincerely,

Marty L Stevenson

Marty L. Stevenson
Regional Manager

Based on having worked on the Nuisance Algae Project from 1989 to present, there are certain items I would like to see removed from "voluntary status" and instead become budget items in the State and or County fiscal budget plans. Those items are listed below.

Based on Marc Hodges' data, turbidity above the State standard is seen at all but one basin. This substantiates the need to have annual cleanings of the basins paid by the appropriate government agency. Words like "cleaned as needed" and notify Maui County of Public Works "in the spring of cleaning needs" does not provide for budgeted money for equipment or workers to do needed cleaning.

Removal of Algae

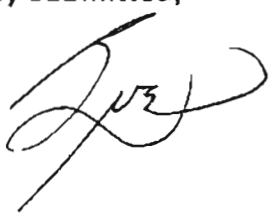
Volunteers being paid a bounty for bags of algae provides a good will community effort and inspiration. However, regular algae removal from the beaches by the County is required by law (despite the County's concern that the State must get it out of the water). There is enough documentation to show that hypnea and ulva are constant as nuisance algae and County funded removal is required.

Sedimentation from Agricultural erosion and construction zones

State laws protect the reefs and ocean waters from receiving any matter that changes it's color, etc. Yet muddied views of the ocean are seen year around from runoff. Again there is enough evidence (Marty Stevenson) to require that state-owned conservation lands, agricultural lands and construction sites keep their soil (and debris) on the land and out of the ocean, streams and waterways. I would like to see a joint effort among the State, agricultural companies and construction companies to hire staff to write grants for erosion control. Wendy Wiltse has shown how grant money can be obtained, it is now the responsibility of those who's runoff enters the ocean to comply to the Clean Water Act and State DOH laws. Perhaps by multiple requests for funding for erosion, a new recognition of clean ocean environments will be given greater priority by funding sources. It is all in how money is managed and spent.

Respectfully submitted,

Eve Clute



APPENDIX E

SUMMARY OF PROPOSED BEST MANAGEMENT PRACTICES FOR AGRICULTURE IN WEST MAUI

Based on March 28, 1997 workshop

NOTE: BMPs that received the most votes are marked by ✓

I. BMPs to improve erosion control . . . in fields.

A. Reduce runoff generated from plastic mulch in newly planted pineapple fields.

- ✓ Revise field layouts and block them more in line with contours.
- ✓ Use cross ditches to break flow along sheets of mulch.

  In steep areas, plant pineapple crowns between sheets of mulch to break the flow of water.

  Use pineapple residue as mulch between sheets of plastic.

  When laying mulch, furrow along the planting line so that water flows toward plants.

  Intercropping. Plant another crop at the end of pine blocks to intercept water flow.

B. Reduce runoff from areas between rows of coffee plants.

Rip the interrows periodically to improve infiltration.

Use permanent perennial cover crops between rows (e.g. oats, burr clover) to hold soil.

C. Reduce runoff from fallow or newly planted cane fields.

- ✓ Plant parallel to terraces instead of across terraces.
- ✓ Install temporary terraces, basins and ditches in fallow or abandoned fields.

  Grow 1 or 2 ratoon crops with deep subsurface irrigation for a 6-year crop cycle and allow a trash blanket to accumulate on soil.

  Intercycle. Use a cover crop between harvest and planting if field will be fallow for some time.

D. General "in field" BMPs for all crops.

- ✓ Harvest and plant sensitive areas in summer.
- ✓ Provide training and education for equipment operators so they understand and appreciate the design and maintenance of erosion control BMPs.
- ✓ Determine if there's a water barrier in the soil. If so, break it up by plowing deep to allow better infiltration.

II. BMPs to improve erosion control . . . outside fields.

A. Improve the function and increase infiltration of water in terraces and diversions.

- ✓ Plant vegetation (e.g. Sudex) on diversions/terraces.
- ✓ Repair and maintain terraces/diversions during the growing cycle.

  Create furrows in portions of terraces to increase infiltration.

B. Reduce erosion on roads.

- ✓ Establish vegetated filters along edges of fields and roads. Best if multispecies, multilayer vegetation.
- ✓ Establish a groundcover for road sides (e.g. vetirer grass).
- ✓ Use closely spaced water bars in roads to break flow and divert water into fields or filter strips.
- ✓ Use soil polymers to bind soils for steep road segments.

C. Other BMPs using vegetation to reduce runoff.

- ✓ Establish permanent grassed waterways.

  Establish permanent rows of plants to act as a "bioterrace."

  Establish filter strips in the gulches and drainages using star grass, California grass.

D. Improve sediment retention in streams.

Install sediment retention basins in series on streams.

Establish artificial wetlands in conjunction with a series of basins to filter fine particles and remove nutrients.

Construct sediment and water retention systems at high elevation and use water for irrigation.

E. General BMPs.

Consult with NRCS on BMP design before planting.

Establish requirements for design of drainage systems for development projects so that downstream impacts on the drainage system are considered, not just individual projects on a piecemeal basis.

Control feral animals in forests to reduce erosion.

Install geotextile in steep or high erosion areas.

III. BMPs to improve nutrient management and minimize loss of nutrients.

- ✓ Use precision agriculture to ensure careful application of fertilizer and pesticides based on local soil/crop needs.

APPENDIX F

FINDINGS AND RECOMMENDATIONS REGARDING NUISANCE ALGAL BLOOMS ON MAUI

The extensive research program directed at understanding the causes of macroalgal blooms on Maui and identifying management actions to control the blooms is now close to completion. The research program was supported by Hawaii Department of Health, the U.S. Environmental Protection Agency and National Oceanic and Atmospheric Administration. The program to date has generated 12 technical reports which were peer reviewed by nationally recognized experts in applicable fields. Based on the technical reports and peer reviews, the West Maui Watershed Advisory Committee developed the following list of findings and management recommendations. The list includes recommendations for further research needed to provide final answers to management questions.

Findings

1. *Hypnea* distribution and abundance

Hypnea musciformis, an introduced red alga, grows in dense aggregations at specific locations in shallow water very close to shore.

Because *Hypnea* has persisted in the same areas for approximately 10 years, it is not expected to disappear or decline rapidly in the near future.

2. Nutrient sources and their importance to *Hypnea*

Oceanic nutrients are not sufficient to support the observed abundance of *Hypnea;* additional inputs of land-derived nutrients are necessary to account for the dense *Hypnea* growth.

The input of nutrients from land contributes to elevated nitrogen and phosphorus concentrations nearshore. Nutrient concentrations decline rapidly with distance away from shore.

Ground water is the major source of nutrients in the nearshore waters where *Hypnea* is abundant.

Over the entire West Maui coastline, the major input of nitrogen to groundwater is from leaching of fertilizers. While natural groundwater that enters the ocean near the shoreline contains higher nutrients than oceanic water, the nutrient levels are increased further by man's activities on land, primarily from fertilizers used on agricultural crops, and disposal of sewage in cesspools.

Nitrogen is not a limiting nutrient for *Hypnea;* it is present in nearshore waters in excess of the amounts needed to support the *Hypnea.*

Cesspools of coastal residences that are not connected to the municipal sewer are another major source of nitrogen and phosphorus at some locations, but it is unclear to what extent nutrients from cesspools contribute to algal growth.

Urban runoff contains high concentrations of dissolved phosphorus, probably from fertilizer used for landscaping.

No wastewater plume was found in waters offshore of the Lahaina wastewater injection wells. Wastewater injection wells were not shown to be a significant source of nutrients for *Hypnea*.

Runoff from streams has not been shown to be a highly significant source of nutrients for *Hypnea* by studies conducted during a period of below normal rainfall.

During large rainstorms, the major source of sediments entering streams is runoff from agricultural land. Other sources include runoff from forests and construction sites.

3. *Cladophora* blooms

Although *Cladophora* blooms in 1989 and 1991 were preceded by unusually large rain events, the lack of reoccurrence of a *Cladophora* bloom following January 1997 rains precludes verification of runoff as the cause of *Cladophora* blooms.

4. Oceanographic and meteorological factors

There is no direct evidence that the physical oceanographic and meteorological factors investigated, Pailolo channel currents and sea surface temperature, contribute to algal blooms on Maui.

Recommendations

Develop additional best management practices to improve erosion control on agricultural land, including broader application of the standard practices, improved maintenance of BMPs, and development and testing of new BMPs.

Promote the use of best management practices to reduce runoff and leaching of fertilizers used for landscaping.

Continue to improve the use and efficiency of best management practices for agricultural fertilizers.

Promote beach cleaning and harvesting of drifting algae to help control nuisance accumulations of algae.

Expand investigations of algal blooms and the watershed management approach to be island-wide.

Additional applied research is needed to determine the following:[12]

- Is phosphorus a limiting nutrient for *Hypnea* growth?
- The meaning of the discrepancy between nitrogen budget estimates and algal nitrogen isotope data.
- Do nutrients from coastal cesspools and runoff and leaching of nutrients from fertilizer applications near the shoreline have significant impact on *Hypnea* growth in localized areas and will reducing these sources reduce *Hypnea* biomass?
- Is habitat limitation a significant limiting factor in *Hypnea* distribution?
- What are the locations of nuisance *Hypnea* and *Ulva* populations for Maalaea-Kihei and Kahului-Kuau and what are the adjacent land uses?
- Determine if nitrogen or phosphorus or neither are limiting for nuisance *Ulva* populations in Maalaea-Kihei and Kahului Harbor?
- Is removal of attached algae, *Hypnea* and *Ulva*, a viable control method to reduce nuisance accumulations on beaches without damaging the associated native ecosystem?

[12] Note that funding is not available to support all recommendations at this time.

Conclusions

The research has vastly improved our understanding of algal blooms on Maui. We know that nutrient inputs from land are required to support the large amount of *Hypnea* that occurs at specific locations along the shore; oceanic nutrients alone are not sufficient. *Hypnea*'s main nutrient source is the continuous seepage of groundwater along the shore. Groundwater is influenced by the leaching of nitrates from fertilizers and in some locations by leaching of nitrogen and phosphorus from cesspools. Oceanic nutrients, wastewater injection wells at the Lahaina Wastewater Reclamation Facility and stream discharges during rain events were ruled out as important sources of nutrients for *Hypnea*. Nitrate, commonly a limiting nutrient for marine algae, is not limiting for *Hypnea* in West Maui because nitrate is present in nearshore waters in excess of the amounts needed to support the *Hypnea*. Other factors such as availability of suitable algal habitat, water motion, and a high growth rate in nutrient enriched waters combine to control *Hypnea* abundance and distribution.

Because *Hypnea* has persisted in the same areas for approximately 10 years, it is not expected to disappear or decline rapidly in the near future. More work is needed to determine whether reducing nitrogen or phosphorus inputs from human activities on land will reduce *Hypnea* abundance. Meanwhile efforts are underway to (1) reduce the nuisance impacts of *Hypnea* by harvesting algae from beaches and shallow waters and converting it to products of commercial value, (2) apply improved best management practices for fertilizer use, and (3) expand the investigation of algal blooms and the watershed management approach to other areas on Maui.

Sediment runoff contributes to high turbidity in nearshore waters. Lack of water clarity can stress coral reef communities and is an aesthetic problem for coastal resorts and the ocean recreation industry. Sediment runoff was not found to be an important factor for *Hypnea* growth. During large rainstorms, the major source of sediments entering streams is runoff from agricultural land. Efforts are underway to reduce sediment runoff by (1) improving erosion control for agricultural land and construction sites, (2) constructing and maintaining sediment retention basins in streams, and (3) protecting native forests.

WEST MAUI WATERSHED MANAGEMENT PROJECT ADVISORY COMMITTEE

Dr. Wendy Wiltse, Hawaii Dept. of Health, Coordinator

Dr. June Harrigan-Lum, Lead for Hawaii Department of Health

Christine Andrews, University of Hawaii

Gina Aranki, West Maui Taxpayers Association

Janet Ashman, Hawaii Agricultural Research Center

Eve Clute

Robert Derks, Kapalua Land Company

Dr. Steve Dollar, U.H. School of Ocean and Earth Science and Technology

Jeff Eng, Kaanapali Resort

Kimo Falconer, Pioneer Mill Co., Kaanapali Estate Coffee, Inc.

Neal Fujiwara, Natural Resource Conservation Service, Maui

Don Gerbig, AMFAC Hawaii

David Goode, County of Maui, Dept. of Public Works & Waste Management

Wil Leon Guerero, Hawaii Department of Agriculture

Skippy Hau, State Dept. of Land & Natural Resources, Division of Aquatic Resources

George Kaya, Mayor's Office, Maui

Ellen Kraftsow, Maui Board of Water Supply, Water Resources & Planning Division

Dennis Nakamura, Maui County Council

Buddy Nobriga, West Maui Soil and Water Conservation District

Wesley Nohara, Maui Pineapple Company

Steve Parabicoli, County of Maui, Dept. of Public Works & Waste Management, Wastewater Reclamation Division

Dr. Frank Peterson, U.H. Dept. of Geology and Geophysics

Dr. Glenn Shepherd, Retired Geologist

Will Spence, Maui Planning Department

Daren Suzuki, Maui Planning Department

Marty Stevenson, Kinnetic Laboratories, Inc.

Allen Tom, NOAA Hawaiian Islands Humpback Whale National Marine Sanctuary

Mahalo to Sherri Carden for drawings and Sara Patton for design and production

For more information about the West Maui Watershed Management Project, contact the Hawaii Department of Health, Environmental Planning Office, 919 Ala Moana Blvd., Honolulu, HI 96814 or call (808) 586-4337.

WHAT YOU CAN DO TO PROTECT THE OCEAN

To control runoff and erosion:

- Use more plants and less pavement.
- Divert runoff from pavement and roof drains onto grass or other vegetation.
- Don't overwater. Use drip irrigation.

To minimize nutrient build-up:

- Use less fertilizer. Choose slow-release fertilizer and apply it conservatively.
- Use phosphate-free biodegradable soaps and detergents.
- Use the bathrooms on shore before going out in a boat. Boaters use the sewage pumpout station at Lahaina Harbor, or discharge marine sanitation devices in deep water.

To control bacteria and viruses:

- Never put grease down the drain. It's the #1 cause of raw sewage spills.
- Pick up animal feces and put in trash or toilet.
- Keep garbage dumpsters covered.

To control toxic chemicals:

- Tolerate more bugs and use fewer pesticides. Use, store, and dispose of pesticides according to instructions on the label.
- Recycle used motor oil and car batteries.
- Learn about safe alternatives to household hazardous chemicals.
- Dispose of household wastes properly. Never put oil, paint, or antifreeze down a storm drain.

PREVENTING POLLUTION IS MUCH EASIER THAN CLEANING IT UP!

To reduce marine debris:

- Recycle plastic, aluminum cans, glass, cardboard, and tires.
- Buy products made from recycled materials.
- Select products with minimal packaging and reusable containers.

To conserve water and energy:

- Repair leaks and install water-saving showerheads and toilet flappers.
- Learn about xeriscaping (landscaping to conserve water use).

To preserve the reef:

- Don't feed the fish.
- Avoid touching and walking on live corals.
- Use permanent day-use moorings where available. Otherwise, anchor in sand or rubble.

To take action:

- Stencil on storm drains in your neighborhood: DON'T DUMP . . . DRAINS TO OCEAN.
- Adopt and clean up a beach, reef, or stream.
- Teach awareness to children and friends.
- Volunteer to monitor beaches and coastal waters. Join Na Pale O Ke Kai.

For more information about The West Maui Watershed Management Project, contact the Hawaii Department of Health, Environmental Planning Office, 919 Ala Moana Blvd., Honolulu, HI 96814 or call (808) 586-4337.